HIGH EXPLOSIVES

DU PONT

HIGH EXPLOSIVES CATALOG

FIRST SECTION

HIGH EXPLOSIVES

Their Manufacture, Handling, Storage, and Use

FIRST SECTION

E. I. DU PONT DE NEMOURS & CO.
INCORPORATED

Established 1802 WILMINGTON, DELAWARE

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Preface

FEW people realize to how great an extent modern progress is dependent upon the use of explosives. People are accustomed to think of explosives as ammunition for the destruction of human life and game, and to associate even dynamite in their minds with bombs, riots, outrages, and crimes of various kinds. The fact does not occur to them that, whereas ounces of explosives are used illegitimately, millions and millions of pounds are doing necessary and useful work. In reality every modern building represents tons of explosives used in mining the iron ore from which structural steel is made, in quarrying the rock from which cement is made, in mining coal to generate the power and heat for making the steel and cement, in constructing the roads and canals and in deepening the channels, through which all these materials are transported.

Iron and steel for every kind of machinery, copper for all kinds of electrical apparatus, lead for the manufacture of paints, zinc for galvanizing sheet iron, and silver and gold are all mined with explosives. No coal, whether bituminous or anthracite, can be mined economically without the use of explosives. Graphite for pencils, rock salt for freezing ice cream, talc for face powders, gypsum for wall plaster, lime for mortar, broken stone for building roads—all these things and many more are absolutely dependent for their economical production upon the use of explosives. The farm and orchard have become consumers of explosives in large and increasing quantities.

Industries as we know them now, without explosives would come instantly to a standstill. This is no stretch of the imagination, but a cold, hard fact. Industrial explosives, with which this catalog deals, are necessary tools of civilization.

PARTIAL VIEW OF THE REPAUNO (N. J.) WORKS OF E. I. DU PONT DE NEMOURS & CO., INC.

High Explosives

The term high explosives, as applied to blasting compounds, includes all of those explosives which can be properly fired only by means of an intermediate detonating agent, such as a blasting cap or electric blasting cap, and not by simple ignition, as are low explosives. High explosives differ from low explosives, such as blasting powder, in that they explode with much greater rapidity, and except in the case of permissible explosives, have more of a shattering effect. They include the nitroglycerin, ammonia, and gelatin dynamites and the Judson Powders. Du Pont Straight, Red Cross Extra, Blasting Gelatin, and the permissible explosives are all examples of commercial high explosives.

In order to be uniformly effective, explosives must possess certain properties, the most important of these being *strength or disruptive* power and *quickness or shattering power*. Other important characteristics are sensitiveness, density, resistance to cold and to moisture, the nature of the fumes evolved, and stability or the power of keeping. Upon all these properties depend the usefulness of an explosive and the safety with which it may be handled. The production of explosives which will possess these properties in the correct proportion to adapt them to the various uses to which they are put requires long experience, skillful labor and supervision, the highest quality of ingredients, complicated and expensive machinery, and the continual testing of the ingredients, processes, and finished products.

The Du Pont Company began the manufacture of explosives in this country in 1802. Today it has mills in all parts of the United States, one of these, the Repauno plant in New Jersey, being the largest dynamite factory in the world. No other explosives manufacturing concern in this country maintains a greater number of technical chemists than are engaged at the Du Pont laboratories. These chemists are employed in testing the daily output of the factories to prevent any deviation from standards, and in studying and experimenting with explosives in order to improve them.

A corps of experts in the use of explosives is also maintained, whose duty is: first, to make a study of the exact requirements of explosives in the various fields and under the widely differing conditions where they can be used to advantage, and to report to the

NITROGLYCERIN HOUSE. HERE THE GLYCERIN IS MIXED WITH ACID IN THE COOLED STEEL TANK, MAKING NITROGLYCERIN

NITROGLYCERIN STOREHOUSE, WHERE THE NITROGLYCERIN IS ACCURATELY WEIGHED BEFORE WHEELING IT TO THE MIXING HOUSE

chemical staff what these requirements are; second, to test out thoroughly such explosives when they have been produced, these tests being made in mines and quarries under every possible condition and usually requiring several months' time; and third, to instruct consumers in the use of explosives, explaining and demonstrating the qualities and action of the different kinds. Although this system is so expensive that only the great quantity of explosives which we sell warrants it, experience has taught us that it is the only way to maintain the highest quality in our explosives, to furnish customers promptly exactly what they need to insure maximum results at a minimum expense, and in every way to maintain our position as the leading explosives manufacturers of the world.

In recent years, the Du Pont Company has brought about improvements in the general efficiency, reliability and stability of explosives, whereby they give maximum results in blasting, have become comparatively safe to handle, and can be kept, under proper storage conditions, for long periods without deteriorating. As a result, it has been possible to dig canals, build railroads and mine low-grade ores to an extent which otherwise would have been out of the question. An explosive has been produced especially adapted for almost every kind of work. Consumers are furnished with detailed instructions as to the proper use of each kind of explosive. The production and storage points are now so widely distributed that it is possible to deliver explosives promptly to any part of the United States. This advance in the making and distributing of explosives has brought about their employment in so many new fields and for so many new purposes that their use has become general and almost all progress is now, either directly or indirectly, dependent upon them.

Manufacture of High Explosives

The high explosives generally used in blasting operations consist of a mixture of nitroglycerin or other primary explosive ingredient, an absorbent to carry the liquid explosive, such as wood pulp, and an oxygen-bearing salt, such as nitrate of soda.

Their manufacture involves not only the mixing of the principal ingredients and packing them for shipment, but also the preparation of the various ingredients used.

The nitroglycerin operation is perhaps the most important in a high explosives plant. It involves the nitration of glycerin by the use of a nitric and sulphuric acid mixture. These acids may either be made on the plant or purchased from regular manufacturers.

Sulphuric acid is manufactured by a number of processes, all of which involve the production of sulphur dioxid gas from sulphur or sulphur-bearing materials, the conversion of the sulphur dioxid gas to sulphur trioxid, and the absorption of this gas in water.

Nitric acid is usually produced by the decomposition of nitrate of soda with sulphuric acid, the gas formed by this treatment being condensed and forming liquid nitric acid.

In the manufacture of nitroglycerin, sulphuric and nitric acids are mixed in the proper proportions and commercial refined glycerin, ordinarily sold as "dynamite glycerin," is treated with this acid mixture to produce nitroglycerin, proper provisions being made to absorb the heat of reaction. The nitroglycerin is allowed to separate from the acid mixture and is subsequently purified and neutralized. After the separation of the nitroglycerin the acids are separated from each other, concentrated, and again used.

If straight nitroglycerin dynamite is to be produced, the purified nitroglycerin is mixed with an absorbent and other materials, properly proportioned. For ammonia dynamite, nitrate of ammonia is substituted for some of the nitroglycerin and sodium nitrate. To make gelatin dynamite, the nitroglycerin is gelatinized with nitro-cotton before being mixed with the other ingredients. The proportion of nitroglycerin and of other materials is varied in accordance with the uses for which the explosives are intended.

After the mixing, the dynamite is packed in paper shells. These cartridges are subsequently packed in wooden boxes ready to be delivered to the trade.

While the foregoing covers the essential steps in the preparation of high explosives, the scientific work of the past few years has taught the progressive manufacturer how to modify his operations so as to obtain in the finished explosive the characteristics that are necessary to give satisfactory service under various conditions and with the various kinds of material to be

blasted. To manufacture explosives with specific characteristics for different classes of work, special formulae, a very elaborate equipment, and the closest attention to details are required.

In the preparation of explosives for mining purposes, for instance, the Du Pont Company has given particular attention to the nature of the fumes given off by the detonation of the explosives. As the efficiency of an explosive depends directly on the volume of gas evolved, the end aimed at is not to reduce the *quantity* of gas given off, but to make the explosive of ingredients which, combined in the *proper proportions*, will reduce to a minimum *objectionable* gases.

In developing the formula for an explosive, it must be assumed that the detonation will be complete. When a charge of high explosives is imperfectly detonated, or detonated without being properly tamped, the gases given off may be very different in volume and composition from those produced when a sufficiently strong detonator is used and the bore hole tamped as it should be. The detonator to be used with an explosive is always specified.

If a weaker detonator than that which we recommend be used, or the bore hole be insufficiently tamped, not only will the volume of gas generated by the explosion be smaller, resulting in inferior execution, but the gases may be very obnoxious or even dangerous to workmen and draft animals. Instances have been known in underground work where workmen have been killed by the poisonous gas evolved by the imperfect or incomplete detonation of explosives. This same trouble may occur in a limited degree when an explosive is used in work for which it is not intended, as, for instance, when an explosive designed for outside work is used underground, or one designed for dry work is used where water is present.

Testing Du Pont High Explosives

Experimental and testing work are important features at every Du Pont plant.

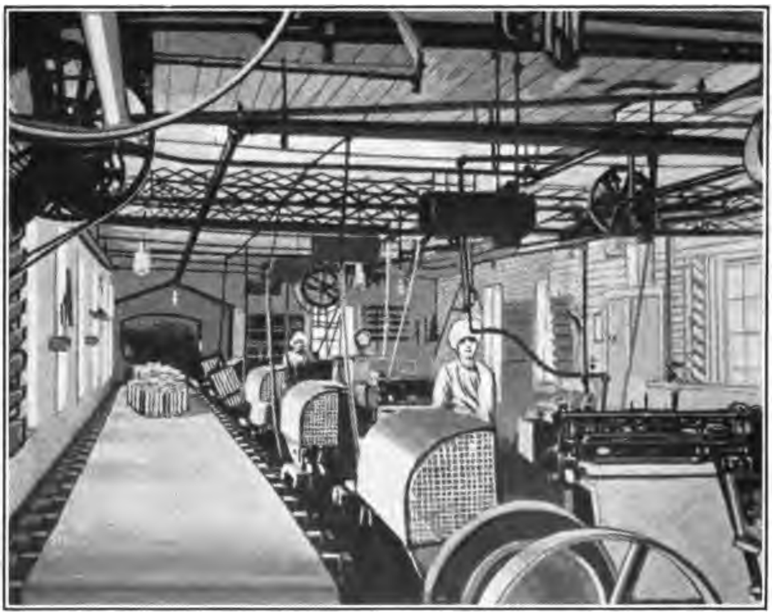
One vital factor in making a successful product is to see that the raw materials that go into it are of the required quality. This feature is given the strictest attention at all Du Pont plants, all materials being rigidly inspected and tested, and any not coming up to the high Du Pont standard being rejected. Likewise, during the process of manufacture Du Pont high explosives are subjected to continual tests. Nothing is left to chance.

At each of our works we have completely equipped laboratories manned by skilled chemists, men who by their education, training, and experience in the manufacture and use of high explosives have qualified as experts in their chosen field.

The various testing apparatus used by this company embody many unique and valuable features invented by our own men.

When you buy and use Du Pont high explosives you have the assurance that no detail has been neglected which would, in the slightest way, tend to bring about perfection of result.

MIXING HOUSE, WHERE THE NITROGLYCERIN IS THOROUGHLY INCORPORATED WITH AN ABSORBENT TO MAKE DYNAMITE



HERE ARE MADE THE PAPER SHELLS INTO WHICH DYNAMITE IS LOADED. THE LOADED SHELLS ARE KNOWN AS CARTRIDGES

Handling High Explosives

If high explosives are handled sensibly and with due regard to their properties, they can be handled with comparative safety. With some consumers, however, familiarity seems to breed contempt and injury or death is the result. During every stage of the production of high explosives, those engaged in their manufacture handle them with the greatest caution and respect; but frequently they have no sooner come into the possession of the consumer than they are knocked about, thawed around open fires, the cases opened with a pick, with the sharp point of a rock, or by dropping on the ground. The Du Pont Company desires to impress the consumer with the fact that carelessness in the handling of explosives is always dangerous and likely to be very expensive. The man who handles dynamite roughly or carelessly, perhaps with the desire to "show off," is not a competent blaster, but a menace and peril to all. A thorough observance of the "Don'ts" in the back of this book will minimize the likelihood of accidents from explosives.

All persons shipping explosives must comply with the Interstate Commerce Commission Regulations for Transportation of Explosives, copies of which can be procured from the Bureau of Explosives, Underwood Building, New York City.

The federal law provides, by an act of Congress of March 4, 1909, effective January 1, 1910, in Sections 232, 233, 234, 235, 236, and 345, that it is a criminal act:

To carry, or cause to be carried, any explosives (other than exceptions named) on any train, boat, trolley, or other vehicle carrying passengers for hire; or

To deliver, or cause to be delivered, to a common carrier for transportation, any explosive under false or deceptive marking or description on package, invoice, or shipping order; or

To violate or cause to be violated any regulation of the Interstate Commerce Commission relating to the marking, shipping, or handling of explosives.

A violation of any of the provisions of this law is punishable by a fine of not more than $2000 or imprisonment for not more than eighteen months, or both; or, if death or injury results from such violation, by imprisonment for not more than ten years.

Therefore, persons engaged in handling, shipping, or delivering explosives should understand that they are personally liable to these penalties and no instructions should be followed which will cause a violation of the above act or of the Interstate Commerce Commission Regulations.

The following precautions should always be observed in shipping, storing, handling, or delivering explosives or while near explosives:

A competent person should always be in charge of explosives, of magazines in which explosives are stored, should keep magazine keys, and should be responsible that all proper safety precautions are taken.

If artificial light is needed, use only an electric flash light or electric lantern.

Do not use oil burning or chemical lamps, lanterns, candles, or matches.

Keep constant watch for broken, defective, or leaky packages.

Do not allow metal bale hooks or other metal tools to be used.

Do not open or re-cooper packages with metal tools.

Do not use empty high explosives cases.

Do not throw packages of explosives down violently or slide them along floors or over each other, or handle them roughly in any manner.

Hauling Explosives

When transporting explosives by team or truck always keep the body thoroughly swept out, and when using an open body protect the load from the sun's rays, rain, and snow with a canvas covering. Store the cases of explosives so that they will not shift. *Never haul detonators and explosives together.*

In transporting explosives avoid all unnecessary stops. Do not haul through cities, towns, or villages when possible to avoid it, but where this is necessary keep off congested thoroughfares, street-car tracks, and dangerous crossings.

PACKING THE CARTRIDGES INTO WOODEN CASES READY FOR THE MARKET

Do not leave any vehicle containing explosives unless team is securely tied and brakes set, or, if motor truck is used, motor is stopped and brakes set.

Do not carry blasting caps or electric blasting caps on a vehicle containing other explosives.

Do not carry metal tools in the body of a vehicle transporting explosives.

When explosives are on vehicles without tops they should always be protected from sun and weather by a tarpaulin.

Vehicles and harness used for transporting explosives should always be kept in first-class repair. Do not run any risk of vehicles or harness breaking down.

Unloading Cars of Explosives

Cars should be unloaded promptly in compliance with the Interstate Commerce Commission regulations.

When cars are opened, retain all seals and take record of seal numbers.

Cars containing explosives should be securely locked or guarded when not being loaded or unloaded. To prevent fire, all leaves, grass, trash, and debris should be removed to a safe distance from cars.

In loading or unloading explosives, great care must be taken to prevent sparks from passing locomotives falling in vehicle. Car doors facing parallel track should be kept closed at all times. When unloading in railroad yards, with parallel tracks on both sides of car, keep doors closed when locomotives are passing or are within 100 feet of the car.

In unloading cars comply with the requirements of cards tacked on inside of cars.

Where an inclined chute is used it must be constructed of 1-inch planed boards, with side guards 4 inches high extending 3 inches above top face of bottom of chute and, throughout its length, fastened with brass screws. "D" shaped strips or runners, not more than 6 inches apart, and running lengthwise of chute, must be fastened to the upper surface of the bottom board by means of glue and wooden pegs extending through the bottom board and runners. Chutes may be occasionally wiped down with waste moistened with machine oil, but care should be taken that all surplus oil is removed to prevent staining the dynamite cases. A stuffed mattress, 4 feet wide by 6 feet long and not less than 4 inches thick, or a heavy jute or hemp mat of like dimensions, must be placed under the discharging end of chute. (Interstate Commerce Commission Regulations.)

Where explosives are being handled between the floor of a magazine and the floor of a car, the runway, if used, should have no exposed metal. All nail heads, bolts, or screws must be countersunk and there should be no metal bands around the ends.

Don't place explosives on the ground.

If any packages of high explosives are received in leaky or damaged condition, put packages to one side in magazine and make full report in detail to us, giving probable cause of damage.

All placards should be removed from cars after explosives have been unloaded.

After unloading car containing blasting powder, car should be swept out and sweepings destroyed by throwing in water.

Notify railroad company as soon as cars are unloaded.

Storing Explosives

All high explosives should be stored only in fire-proof, bullet-proof, and weather-proof magazines, properly ventilated.

Blasting powder may be stored with high explosives if the magazine is bullet-proof, fire-proof, and weather-proof and properly ventilated.

Blasting caps and electric blasting caps should be stored in fire-proof and weather-proof magazines, properly ventilated.

Blasting caps and electric blasting caps should never be stored in the same magazine with any other explosives.

Keep the door of a magazine securely locked when not engaged in the magazine.

Keep ground around magazines clear of leaves, grass, trash, stumps, or debris to prevent fire reaching them.

If leak develops in magazine roof or walls, repair it at once.

Always ship, deliver, or use oldest stock first.

BALLISTIC PENDULUM, USED FOR MEASURING STRENGTH OF HIGH EXPLOSIVES

When blasting powder and dynamite are both stored in one magazine, store each explosive separately.

Dynamite boxes should be laid flat, top side up. Corresponding grades and brands should be stored together and in such manner that brand and grade marks will show. All stocks should be stored so as to be easily counted and checked and so that oldest stocks can be delivered or used first.

Always be on the lookout for dynamite cases showing stains of any nature caused by leakage of any substance from within the case, and report it immediately.

Magazine floors should be regularly swept and kept clean. Destroy sweepings from dynamite magazine floors by burning.

In case magazine floors become stained with nitroglycerin, scrub well with a stiff broom, hard brush, or mop with a solution composed of one-half gallon water, one-half gallon wood alcohol and two pounds sulphide of sodium. Use plenty of the liquid so as to decompose the nitroglycerin thoroughly.

When magazines require any repairs on the inside of the building, all explosives should be removed to a safe distance and protected. If dynamite has been stored in the magazine and there are any indications of nitroglycerin stains on the floor, wash this portion of the floor before the repairs are undertaken, as instructed in preceding paragraph. In case the floor is badly stained, notify us. In making outside repairs, if there is any possibility of causing a spark, fire, or explosion, the explosive should be removed to a safe distance from the magazine and properly cared for until the repairs are made. While magazines are being repaired, explosives should be protected from the weather. Don't store them on the ground.

Use a wooden wedge and mallet in opening or closing packages of explosives.

Do not have loose dynamite or blasting supplies exposed in any magazine.

Do not pile damaged or unsalable explosives with salable stocks.

Do not keep or use any steel or metal tools in a magazine, or store any commodity except explosives in a magazine.

Do not store any explosives where they are likely to get wet or absorb moisture.

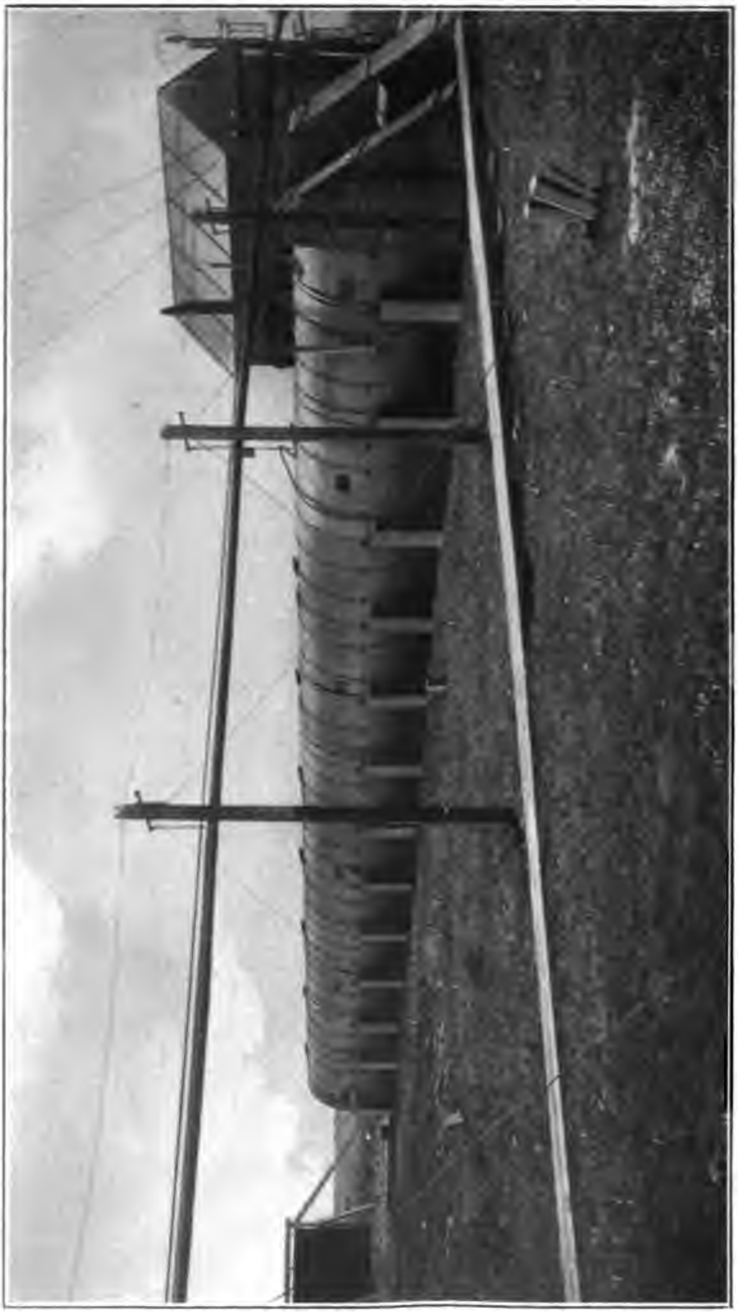
Do not open packages of explosives or pack or repack explosives in a magazine or within 50 feet of a magazine.

Do not leave explosives lying around where children or people can meddle with them. Always keep them under lock and key in a suitable magazine.

Do not store fuse in a hot place. Fuse should be kept cool and dry.

Do not store any explosives in a dwelling, blacksmith shop, barn, or in any place where, in event of an accident, loss of life or property damage might result.

Don't use a magazine for a thawing house.



DU PONT TESTING GALLERY, REPAUNO, N. J., FOR TESTING PERMISSIBLE EXPLOSIVES

Don't store primed cartridges in a magazine; *i.e.*, cartridges with detonator attached.

Post magazine rules in every magazine and comply with them.

Destroying Unsalable Explosives

Whenever it becomes necessary to destroy damaged explosives, immediately communicate with the Du Pont Company for advice and instructions.

Repacking Explosives

When repacking is required or deemed necessary in order to comply with Interstate Commerce Commission Regulations, communicate with the Explosives Bureau, 30 Vesey Street, New York City, or with the Du Pont Company, for advice and instructions.

Thawing Explosives

When it is necessary to thaw explosives, use only the methods recommended in the following chapter of this catalogue.

Shipping Explosives

Railroads must be given twenty-four hours' notice of all less than carload shipments, and their destination.

Comply with the Interstate Commerce Commission's latest regulations. Do not offer for rail shipment explosives that violate Interstate Commerce Commission Regulations.

Interstate Commerce Commission Regulations prohibit the shipment of blasting caps and electric blasting caps in cars containing high explosives.

Cars used for transportation of explosives must be certified, inspected, and placarded in accordance with the Interstate Commerce Commission Regulations.

Condition of shipments must comply with the Interstate Commerce Commission Regulations for transportation and must be packed, marked, loaded, stayed, and handled in accordance with the Interstate Commerce Commission Regulations. Diagrams showing the proper way to load cars may be secured from railroad agents, or from the Bureau of Explosives.

In reshipping original packages to the trade, former markings and addresses must be removed or obliterated.

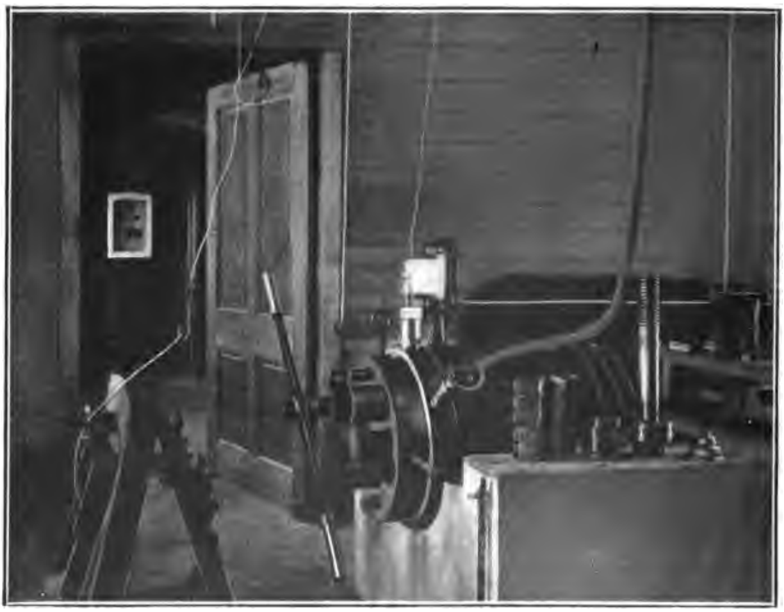
Name of consignee, destination, county, and state must be plainly marked or stenciled on all packages for shipment. Don't use tags or stickers.

When necessary to ship less than original packages of blasting supplies, such packages, packing, and markings must comply with Interstate Commerce Commission Regulations.

Bills of lading covering all shipments of explosives must conform in every detail to the Interstate Commerce Commission Regulations.

Shippers' certificates, as required by the Interstate Commerce

STEEL MORTAR USED AT THE EASTERN LABORATORY FOR TESTING PERMISSIBLE EXPLOSIVES



MACHINE AT THE EASTERN LABORATORY FOR RECORDING THE PRESSURE DEVELOPED BY THE DETONATION OF HIGH EXPLOSIVES

Commission Regulations, must be printed or stamped on the shipping order in the lower left-hand corner and signed by shipper.

Under this certificate the offering for shipment of any forbidden explosives, cases of dynamite showing stains of any nature caused by leakage of any substance from within the case, explosives not packed in accord with Interstate Commerce Commission Regulations, or any explosives misnamed on the package or on the shipping order, is a violation of Section 235 of Act of Congress of March 4, 1909, and punishable by fine and imprisonment.

Always ship oldest stock first, but do not offer for shipment broken or leaky cases of dynamite or kegs of powder or any stock which does not comply with Interstate Commerce Commission Regulations.

Empty boxes previously used for dynamite must not be used again for shipment of any character.

Empty dynamite boxes should be burned by piling a few of them in a pile, pouring a little oil over them, and igniting them by a little straw, shavings, or paper, the person burning them going immediately to a place of safety a few hundred feet distant and remaining until the boxes have burned.

Interstate Commerce Commission Regulations require railroad companies to furnish proper cars for shipping explosives and require that whoever loads the car must furnish the lumber and brace the shipments in accordance with methods prescribed by the Explosives Bureau.

Boxes of explosives must be loaded in the cars top side up, with their long dimension parallel to the length of the car.

Explosives in kegs, except where boxed, must be loaded on their sides with heads toward the ends of the car.

Explosives delivered to railroad station must be loaded, stayed, and braced by railroad company.

A car of explosives must not contain more than 70,000 pounds gross weight.

Types of Magazines

This company has plans and specifications for standard magazines which we will be glad to furnish on request. Ask for Book No. 3—Storage of High Explosives,—Plans and Specifications for Brick Magazine; Book No. 4—Storage of High Explosives,—Plans and Specifications for Sand Filled Magazine; and Book No. 5—Storage of Powder,—Plans and Specifications for Powder Magazine.

All magazines for storing high explosives should be well ventilated and it is desirable that there be lattice-work on the walls to make sure that the dynamite cases will not come in contact with the walls and thus cut off ventilation.

It is recommended that magazine doors always be hung so as to open outward and that, especially for permanent magazines, a lock of the mortise type be used rather than a common padlock.

A LARGE MAGAZINE FOR EXPLOSIVES WITH BARRICADE TO PREVENT FRAGMENTS OF MAGAZINE FROM DAMAGING ADJACENT BUILDINGS ON THE OCCURRENCE OF AN EXPLOSION

A MAGAZINE CONSTRUCTED OF CORRUGATED METAL MAKES A PROPER STORAGE PLACE FOR EXPLOSIVES REQUIRED WHILE WORK IS PROGRESSING

Rules Recommended by the Institute of Makers of Explosives to be Conspicuously Posted in Magazines Containing Explosives

Rules for Dynamite Magazine

Recommended by Institute of Makers of Explosives

1. Store only dynamite in this magazine. Do not store blasting caps or electric blasting caps, inflammables, metal tools or other implements in this magazine.

2. Explosives should be handled carefully.

3. Store dynamite boxes flat, top side up. Corresponding grades and brands should be stored together in such manner that brand and grade marks will show. All stocks should be stored so as to be easily counted and checked, and so that oldest stocks can be shipped, delivered, or used first.

4. Always ship, deliver, or use oldest stocks first.

5. Do not throw dynamite boxes down violently or slide them along the floor or over each other or handle them roughly in any manner.

6. Do not open packages of explosives or pack or repack explosives in a magazine or within 50 feet of a magazine.

7. Use a wooden wedge and mallet in opening or closing packages of dynamite.

8. Do not use metal bale hooks in handling, or metal tools to open packages of explosives.

9. Do not have loose dynamite or open dynamite boxes in this magazine.

10. If artificial light is needed, use only an electric flash light or electric lantern. Do not use oil-burning or chemical lamps, lanterns or candles in or around this magazine.

11. Do not carry or allow others to carry matches or to smoke in or near this magazine.

12. Do not allow shooting nor permit anyone to have firearms or cartridges in or near this magazine.

13. Keep this magazine clean.

14. If leak develops in magazine roof or walls, repair it at once.

15. Keep ground around magazine clear of leaves, grass, trash, stumps, or debris, to prevent fire reaching it.

16. Do not allow unauthorized persons in or near magazine.

17. Keep constant watch for broken, leaky, or defective packages.

18. Do not use empty dynamite cases.

19. If any packages of dynamite are received in leaky or damaged condition, put packages to one side in magazine and make full report in detail to manufacturer, giving probable cause of damage.

20. Keep door of this magazine securely locked when not engaged in it.

Note.—(It is suggested copy of above rules be posted in dynamite magazines for guidance of persons in charge of magazine.)

(Fuse may be stored in same building with dynamite.)

Rules for Powder Magazine

Recommended by Institute of Makers of Explosives

1. Store only powder in this magazine. Do not store blasting caps or electric blasting caps, inflammables, metal tools or other implements in this magazine.

2. Explosives should be handled carefully.

3. Store powder kegs on ends (bungs down) or on sides (seams down). Corresponding grades and brands should be stored together in such manner that brand and grade marks will show. All stocks should be stored so as to be easily counted and checked and so that oldest stocks can be shipped, delivered, or used first.

4. Always ship, deliver, or use oldest stocks first.

5. Do not throw powder kegs down violently or slide them along the floor or over each other or handle them roughly in any manner.

6. Do not open kegs of powder or repack powder in a magazine or within 50 feet of a magazine.

7. Do not have loose powder on a magazine floor, in or around magazine.

8. Open powder kegs by removing the slide or unscrewing the (top) bung.

9. Do not use metal tools to open or close kegs of powder.

10. If artificial light is needed, use only an electric flash light or electric lantern. Do not use oil-burning or chemical lamps, lanterns, or candles in or around this magazine.

11. Do not carry or allow others to carry matches or to smoke in or near this magazine.

12. Do not allow shooting nor permit anyone to have firearms or cartridges in or near this magazine.

13. Keep this magazine clean.

14. If leak develops in magazine roof or walls, repair it at once.

15. Keep ground around magazine clear of leaves, grass, trash, stumps, or debris, to prevent fire reaching it.

16. Do not allow unauthorized persons in or near magazine.

17. Keep constant watch for broken, leaky, or defective kegs.

18. Do not use empty powder kegs.

19. If any packages of powder are received in leaky or damaged condition, put them to one side in magazine and make full report in detail to manufacturer, giving probable cause of damage.

20. Powder kegs should be thoroughly shaken by hand sufficiently often to prevent caking. Don't knock against floor or each other.

21. Keep door of this magazine securely locked when not engaged in it.

Note.—(It is suggested copy of above rules be posted in powder magazines for guidance of persons in charge of magazine.)

(Fuse may be stored in same building with powder.)

Rules for Dynamite and Powder Magazine

Recommended by Institute of Makers of Explosives

1. Store only dynamite and powder in this magazine. Do not store blasting caps or electric blasting caps, inflammables, metal tools or other implements in this magazine.

2. Explosives should be handled carefully.

3. Store dynamite boxes flat, top side up. Store powder kegs on ends (bungs down) or on sides (seams down). Corresponding grades and brands should be stored together in such manner that brand and grade marks will show. All stocks should be stored so as to be easily counted and checked and so that oldest stocks can be shipped, delivered, or used first.

4. Always ship, deliver, or use oldest stocks first.

5. Do not throw packages of explosives down violently or slide them along the floor or over each other or handle them roughly in any manner.

6. Do not open packages of explosives or pack or repack explosives in a magazine or within 50 feet of a magazine.

7. Use a wooden wedge and mallet in opening or closing packages of explosives. Open powder kegs by removing the slide or unscrewing the top (bung).

8. Do not use metal bale hooks in handling, or metal tools to open packages of explosives.

9. Do not have loose dynamite or powder in this magazine.

10. If artificial light is needed, use only an electric flash light or electric lantern. Do not use oil-burning or chemical lamps, lanterns or candles in or around this magazine.

11. Do not carry or allow others to carry matches or to smoke in or near this magazine.

12. Do not allow shooting nor permit anyone to have firearms or cartridges in or near this magazine.

13. Keep this magazine clean.

14. If leak develops in magazine roof or walls, repair it at once.

15. Keep ground around magazine clear of leaves, grass, trash, stumps, or debris, to prevent fire reaching it.

16. Do not allow unauthorized persons in or near this magazine.

17. Keep constant watch for broken, leaky, or defective packages.

18. Do not use empty dynamite cases or powder kegs.

19. If any packages of dynamite or powder are received in leaky or damaged condition, put packages to one side in magazine and make full report in detail to manufacturer, giving probable cause of damage.

20. Powder kegs should be thoroughly shaken by hand sufficiently often to prevent caking. Don't knock against floor or each other.

21. Keep door of this magazine securely locked when not engaged in it.

Note.—(It is suggested copy of above rules be posted in magazine used for storing dynamite and powder for guidance of persons in charge of magazine.)

(Fuse may be stored in same building with dynamite and powder.)

Rules for Blasting Accessories Magazine

Recommended by Institute of Makers of Explosives

1. Store only blasting supplies in this magazine, *i. e.*, blasting caps, electric blasting caps, fuse, blasting machines, etc. Do not store dynamite or powder, inflammables, steel or metal tools or other implements in this magazine.

2. Explosives should be handled carefully.

3. Corresponding grades and brands should be stored together in such manner that brand and grade marks will show. All stocks should be stored so as to be counted and checked easily and so that oldest stocks can be shipped, delivered or used first.

4. Always ship, deliver or use oldest stocks first.

5. Do not throw boxes of blasting supplies down violently or slide them along the floor or over each other or handle them roughly in any manner.

6. Do not open packages of blasting caps, electric blasting caps or fuse until necessary to fill orders or to use them, and then close the package.

7. Use a wooden wedge and mallet for opening or closing boxes of blasting supplies; when lids are screwed on a screwdriver may be used. Do not keep any other metallic tools in this magazine.

8. Do not use metal bale hooks in handling or metal tools to open packages of blasting supplies, except a screwdriver where lids are screwed on.

9. Do not have loose blasting caps, electric blasting caps or coils of fuse in the magazine or take them out of the original package until necessary to fill orders or to use them.

10. If artificial light is needed, use only an electric flash light or electric lantern. Do not use oil-burning or chemical lamps, lanterns, or candles in or around this magazine.

11. Do not carry or allow others to carry matches or to smoke in or near this magazine.

12. Do not allow shooting nor permit anyone to have firearms or cartridges in or near this magazine.

13. Keep this magazine clean.

14. If leak develops in magazine roof or walls, repair it at once.

15. Keep ground around magazine clear of leaves, grass, trash, stumps, or debris, to prevent fire reaching it.

16. Do not allow unauthorized persons in or near magazine.

17. Use extreme care in opening or closing packages of blasting supplies.

18. Keep door of this magazine securely locked when not engaged in it.

19. Do not store fuse in a hot place. Fuse should be kept cool and dry.

Note.—(It is suggested copy of above rules be posted in blasting supply magazines for guidance of persons in charge of them.)

Proper Methods of Thawing Dynamite

In all climates where the temperature falls below the freezing point of dynamite (45° F. or 7° C.) at some time during the year, the question of convenient and safe methods of thawing dynamite is of vital interest to anyone carrying on blasting operations during the winter months. It is the purpose of this chapter to offer suggestions to our customers which will enable them to thaw dynamite safely and as economically as is consistent with their individual needs.

Nitroglycerin explosives of practically all grades freeze at a temperature of from 45° to 50° F. or from 7° to 10° C. Low-freezing dynamites—Du Pont Gelatin, Repauno Gelatin, all kinds of Red Cross explosives, Du Pont RRP, F, FF, and FFF—resist cold much better than the other kinds. Even these low-freezing dynamites will become chilled by long exposure to extremely cold weather and thawing is still necessary. *When in a frozen condition dynamite can never be completely detonated, and often not at all;* when partially detonated, it will give off poisonous fumes or burn up in the bore hole. It is therefore of extreme importance *never to use frozen dynamite.* Some provision must be made for thawing it and also for keeping it thawed until it is loaded into the bore holes.

There are various ways of thawing high explosives, but the only *safe* methods are those which *thaw slowly and gradually.* It is not at all necessary that the cartridges should feel warm; all that is necessary is that they be *soft all the way through.*

Details of various methods of thawing for varying quantities of dynamite are described in the following pages.

Thawing Kettles

Where only a small amount of dynamite will be required, no improvement has yet been made over the thawing kettle. On work where large quantities of explosives are used, thawing houses will be found necessary, but even then, although the kettle may be too small for thawing purposes, it is still a great convenience for carrying explosives from the thawing house to the place where they are to be used, in order to prevent them from becoming chilled or frozen again. If not more than two or three hundred pounds of dynamite is needed at a time, three or four large kettles are all that will be necessary to thaw this quantity thoroughly in a very few hours.

The Du Pont (Catasauqua type) thawing kettle is made in one piece with a water-tight compartment for the explosives, which is surrounded by the receptacle for the hot water.

In using the thawing kettle it is absolutely necessary to heat the water in some other receptacle and then fill the water compartment. Under no circumstances must the water be heated in

the kettle, because of the danger of firing some of the nitroglycerin left in it from the heating of the previous lots of dynamite. The hot water must always be tested before filling the dynamite compartment. If water is hot enough to burn the hand, don't put explosives into the kettle. Never fill the water jacket unless the explosives compartment is empty, and see that the explosives compartment is perfectly dry and clean before it is filled. Dynamite should never, under any circumstances, be permitted to come in contact with hot water.

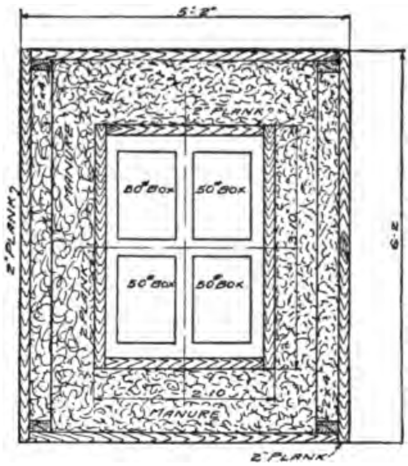
The Du Pont thawing kettle will retain its heat about five times as long if the kettle is placed in a barrel filled with dry hay. A cylinder of wire screen can be made to hold the hay in place, so that the kettle itself may be removed and replaced without disturbing the hay packing. If the barrel is mounted on wheels, the dynamite can be moved from place to place about the work so that it need not be exposed to cold air until it is ready to be loaded in the bore holes.

A simple and effective thawing arrangement may be made by suspending some receptacle filled with dynamite in a larger bucket partly filled with warm water. Care must be taken, however, to prevent the water from getting into the pail containing the dynamite; this pail should have a water-tight lid. The whole should be covered with a piece of carpet or old coat until the dynamite is thawed. When larger quantities of dynamite are required on temporary work, an excellent device is to place the cartridges in a large dry, water-tight milk can, the bottom of which is covered with sawdust, and to set the can in a cask or barrel containing water which has been previously heated by a jet of steam. If steam is not obtainable the cask may be filled with warm water as often as is necessary. If the water in the cask is to be heated by a jet of steam, the milk can containing the dynamite must always be taken out of the cask while the water is being heated. The water must always be tested before filling the dynamite compartment. If the water is hot enough to burn the hand, don't put in the explosives. The cask should be covered with insulating material to retain the heat.

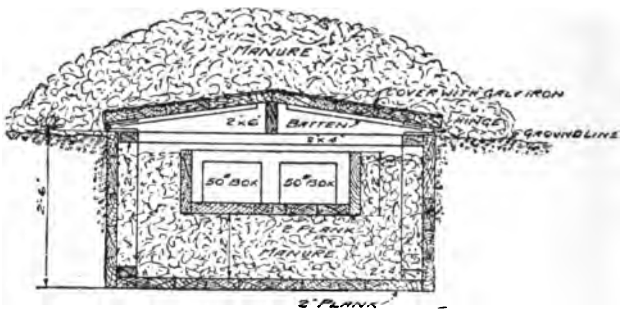
DU PONT THAWING KETTLE

Sizes and Capacities of Thawing Kettles

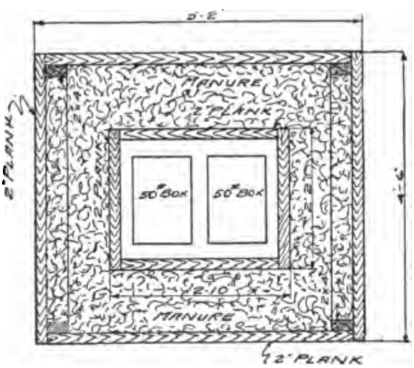
	Capacity In Pounds of Dynamite	Weight Empty	Weight of Water	Total Weight Filled	Outside Dimensions
Du Pont No. 1	30	12½	40	82½	14" x 14½"
Du Pont No. 2	60	17½	7½	155	17½"x 21"



PLAN FOR FOUR 50-LB. CASES



SECTIONAL ELEVATION FOR TWO AND FOUR 50-LB. CASES



PLAN FOR TWO 50-LB. CASES

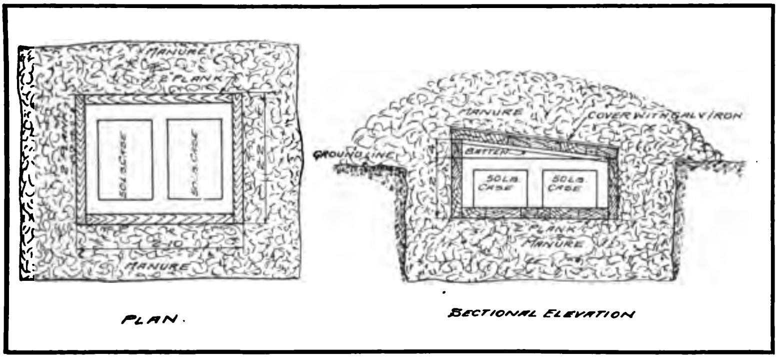
Thawing Boxes

Stable manure is frequently used to thaw dynamite and is fairly satisfactory, always provided it is fresh. Under no circumstances, however, should the cartridges be allowed to come in actual contact with manure, since they might absorb moisture.

Below is shown a manure-filled thawing box for one hundred pounds of dynamite in fifty-pound cases. A box is shown, made of a 2-inch plank, with sloped lid, which may be covered with galvanized iron. This box is placed in a pit of sufficient size to receive it, and at the same time permit the packing of sufficient manure between the box and the earth, on the sides and the bottom and also on the top when the box is in use. The size of the pit will depend on the amount of explosives to be thawed and the amount of manure it is necessary to use as packing. Since the depth which it may be necessary to make this packing varies with the nature of the climate as well as the frequency with which it may be convenient to renew the manure, it is impossible to give definite dimensions for the pit, but *remember* that the ordinary types of dynamite freeze at between 45° and 50° F., and the amount of protection necessary should be judged accordingly.

In the illustrations below the box is designed to hold one hundred pounds of dynamite in fifty-pound cases, but the dimensions may be increased to hold much larger quantities. Be sure, however, in planning the box to have sufficient space (about 2 inches) between cases to permit a uniform thawing and convenient handling, and also have sufficient manure packing to insure complete thawing.

The illustrations on page 30 show a slightly more elaborate arrangement of two boxes, to be used where the nature of the soil makes the outer box advisable or necessary. In this case the pit is dug just large enough to receive the outer box, the manure being packed in the space between the outer and the smaller box which holds the dynamite. The thawing boxes shown in



SINGLE THAWING BOX EMBEDDED IN MANURE

the figure are designed for two and four cases, but may be built for larger quantities. One must always be sure, however, that space is left between the cases.

Tops of cases should be removed before placing dynamite in the thawing boxes.

Thawing House

Heated only by Exhaust Steam

The illustrations on pages 34 and 35 show a type of permanent thawing house *to be heated only with exhaust steam.* Exhaust steam is usually the most convenient and economical heat which can be used, for, on the majority of permanent work where explosives are used, there is an engine or pump, the exhaust steam from which may be utilized at a nominal cost for supplying heat in the thawing house. It is dangerous to use live steam or steam under pressure, on account of the possibility of high temperatures. This house is designed to thaw 500 pounds of dynamite at a time in trays holding fifty pounds each. If it is desired to have a larger capacity, increase the thawing house in units of 250 pounds each (or half the original house) and also increase the radiating surface of the steam coil accordingly. This increase in capacity can be carried out to any extent desired. The amount of radiating surface necessary will vary with the climatic conditions; care must be taken, however, to provide sufficient heat to insure complete thawing. In installing the steam coil, be sure to give the pipes sufficient slope to drain properly. If it is preferred, the same type of coil may be installed in this thawing house as in the one designed for hot water heating, shown on pages 36, 37, and 38.

The packing in the walls of this house is specified as either sand or sawdust. Dry sand is a very good insulating material, but would make ship-lap or tongue-and-grooved boards necessary on the outside walls to hold it in place. Never use *coarse gravel* for packing, on account of missiles which would be thrown in case of an accidental explosion of the thawing house. Dry sawdust is probably the best economic packing to be chosen. Of course, mineral wool or asbestos fibre would give a more perfect insulation, besides being fire-proof, but in some cases the cost would be prohibitive.

A thermometer is placed in the back wall of the thawing house behind a double glass window so that the temperature in the house may be determined without opening the doors and admitting cold air. A damper is also placed in the stack to permit the regulating of the circulation of the air through the house.

90° F. or 32.2° C. is a good thawing temperature.

If it is desired, a small box on wheels or a cart can be made of just the size to receive a certain number of the trays from the thawing house. As many trays as are needed at a time may be placed in the cart, covered and taken to the work without

exposing the dynamite to the cold air until it is ready for loading in the bore holes.

The thawing house should always be kept locked, and only one person allowed access to it. Use a good grade of standard make padlock.

It will be noted that there is no space in this house to permit a person to enter, so that it is impossible to use this house as a place to prime cartridges. Several disastrous accidents have been caused by priming dynamite in the thawing house.

Thawing House

Heated by Hot Water

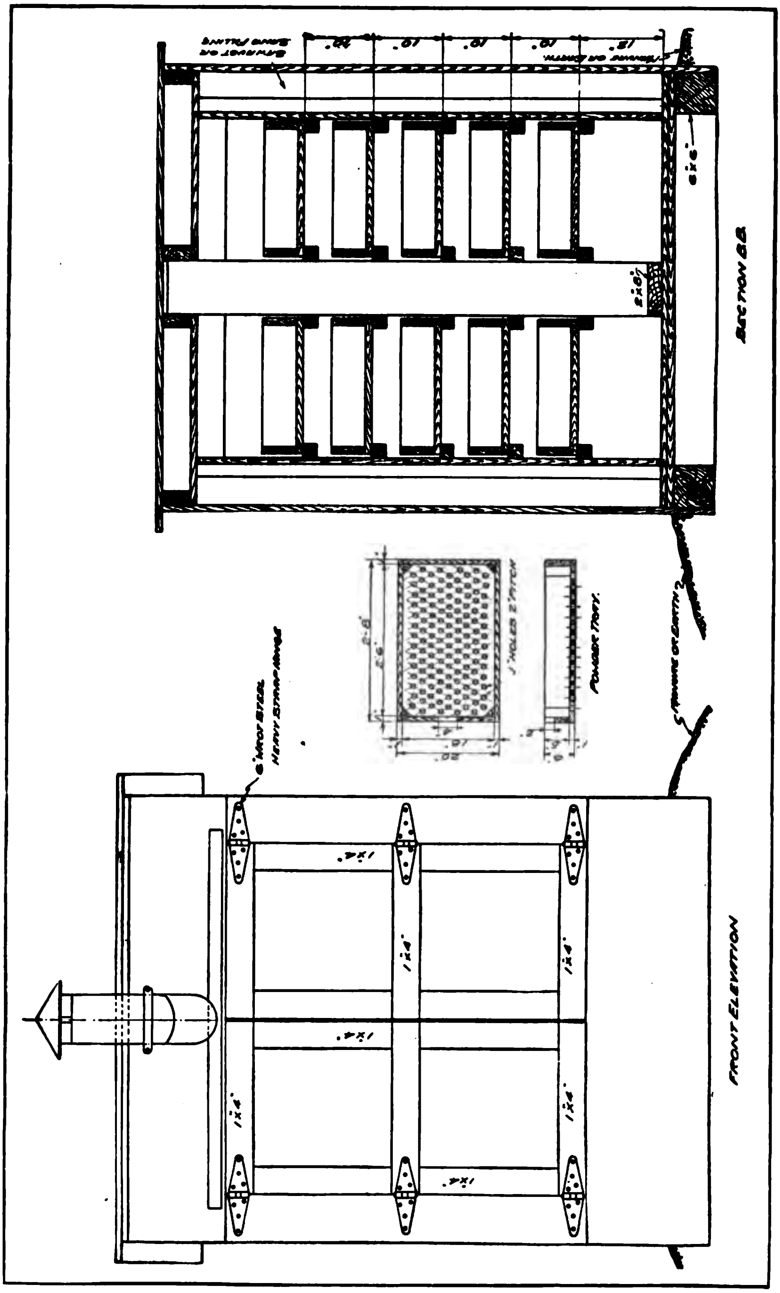
On pages 36, 37, and 38 is shown a permanent thawing house to be heated with hot water. This house is designed to thaw 500 pounds of dynamite at a time, in trays of fifty pounds each. If a greater capacity is desired, increase the size of the house in units of 250 pounds, increasing the radiating surface of the coils and the size of the heater accordingly. All details of construction in regard to the thawing house itself which were taken up in the discussion of the thawing house heated by exhaust steam apply in this case. The illustration shows also a heater house and a standard type of heating unit for small hot water systems. In installing this system, it is imperative that the heater house be enough lower than the thawing house to permit a good gravity flow in the return pipe from the heating coil in the thawing house to the heater. The heater house should be built at a distance of from 30 to 50 feet from the thawing house. Added distance increases the cost of construction, and diminishes economy of operation, while too close proximity to the thawing house adds to the fire risk. The pipes between the buildings which are exposed to the open air should be covered with standard magnesia pipe covering, or placed in a sawdust filled box.

Thawing House

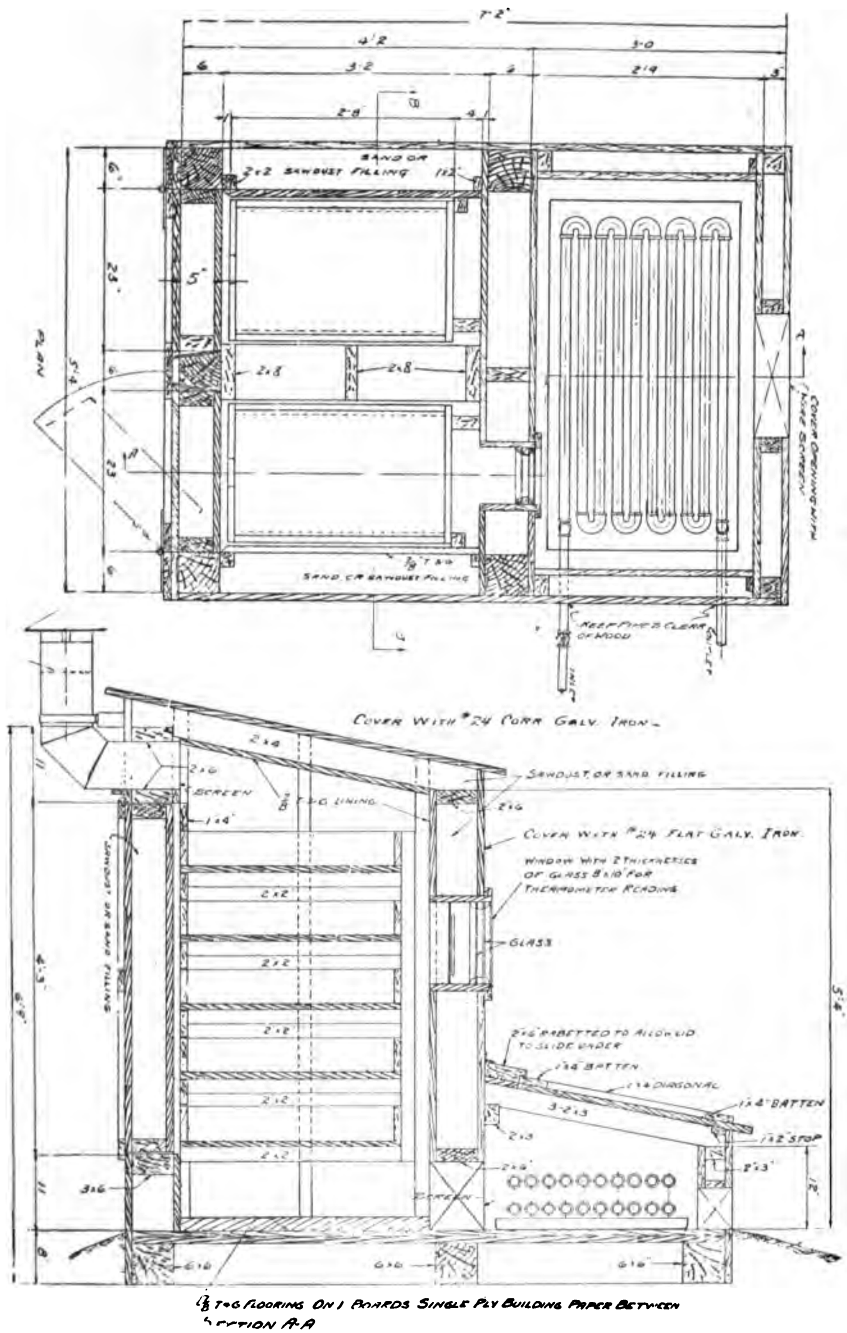
Heated by Exhaust Steam or Hot Water

The illustrations on pages 39 and 40 show a type of permanent thawing house to be heated with exhaust steam or hot water, having a capacity of 5,000 pounds of dynamite each. This house is designed to thaw the dynamite in the original cases in which it is received.

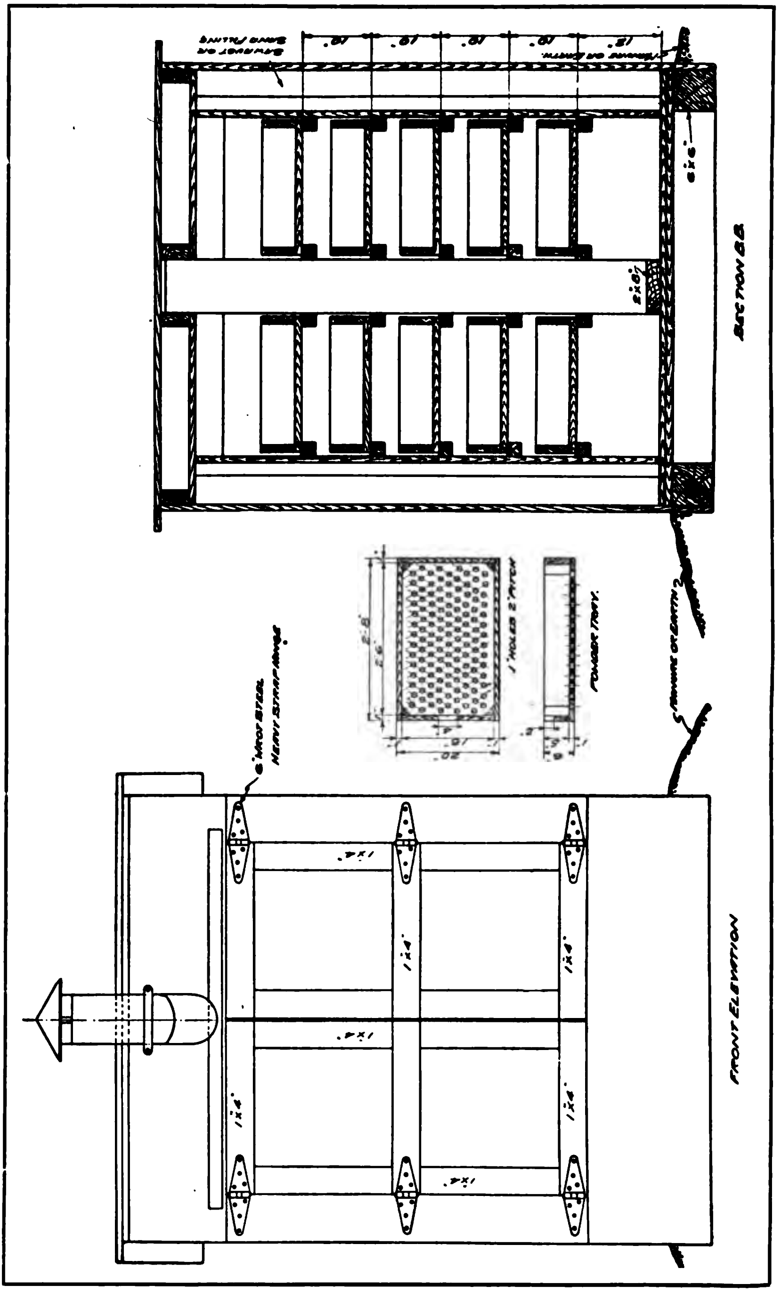
There are three compartments, divided by vertical partitions extending almost to the floor and the ceiling. In the central compartment is the radiator coil or pipe, which is heated by exhaust steam or hot water. On either side of this central compartment the dynamite boxes are placed in horizontal racks so constructed that no nails, screws, or bolts project from the runways. Four racks are built on each side of the heating compartment into each of which five dynamite boxes can be slid from one end of the house to the other. Doors giving access to the



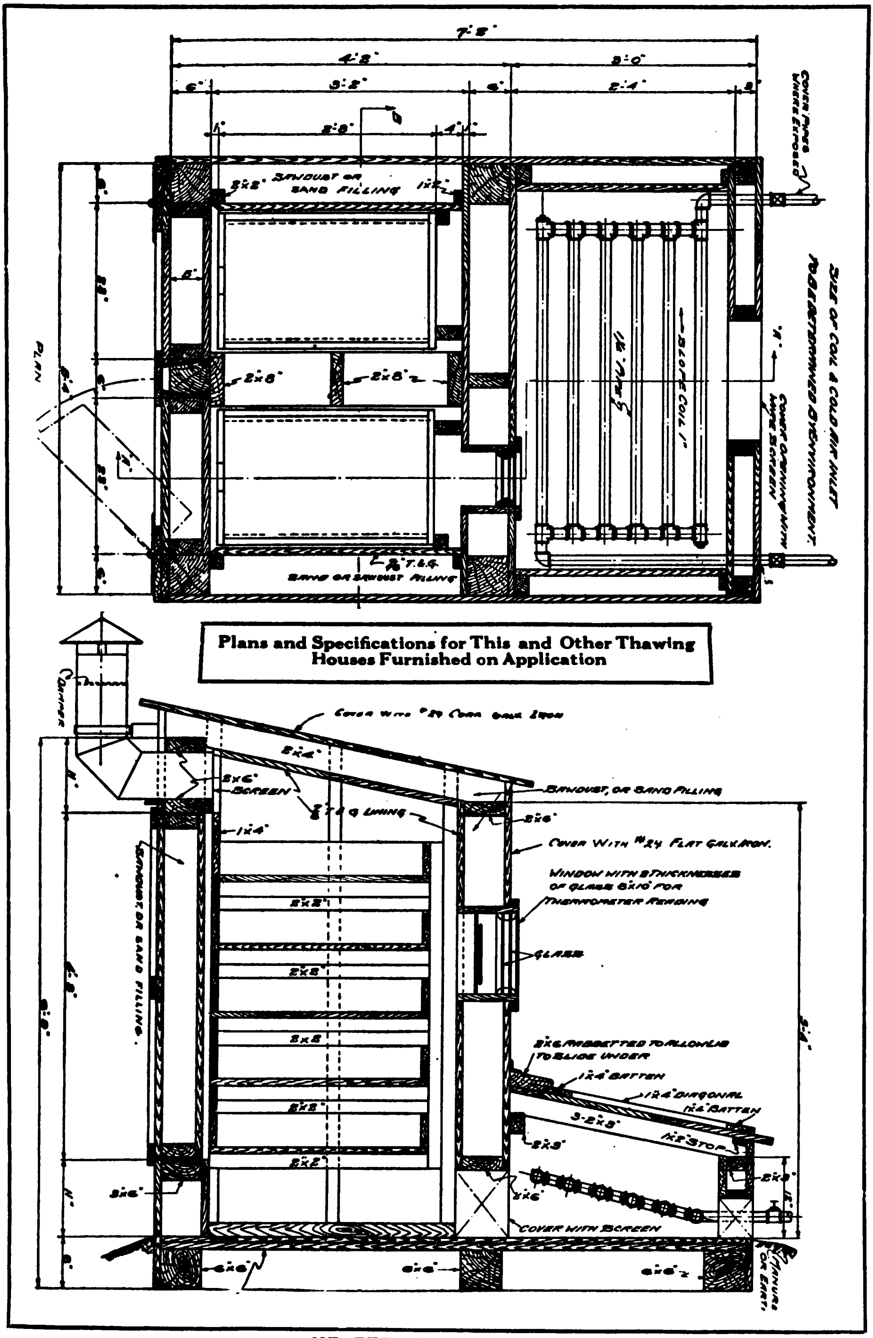
DYNAMITE THAWING HOUSE



HEATED BY EXHAUST STEAM

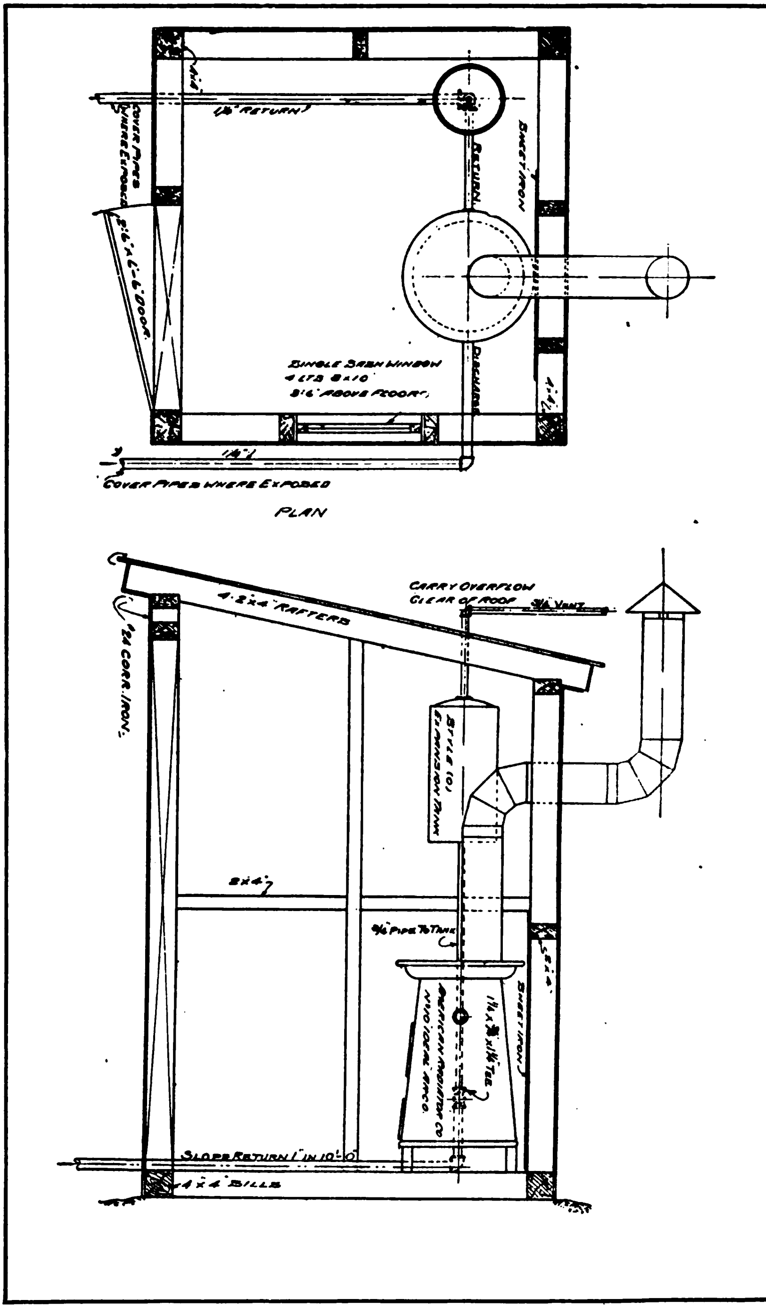


DYNAMITE THAWING HOUSE

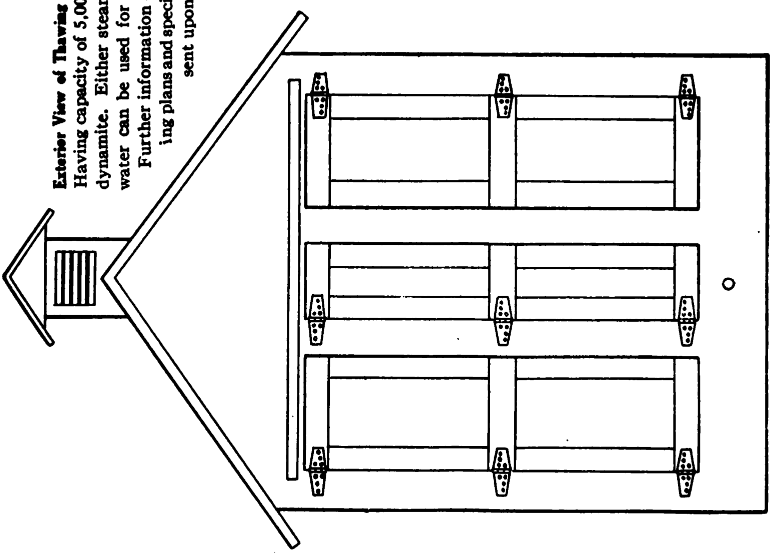


Plans and Specifications for This and Other Thawing Houses Furnished on Application

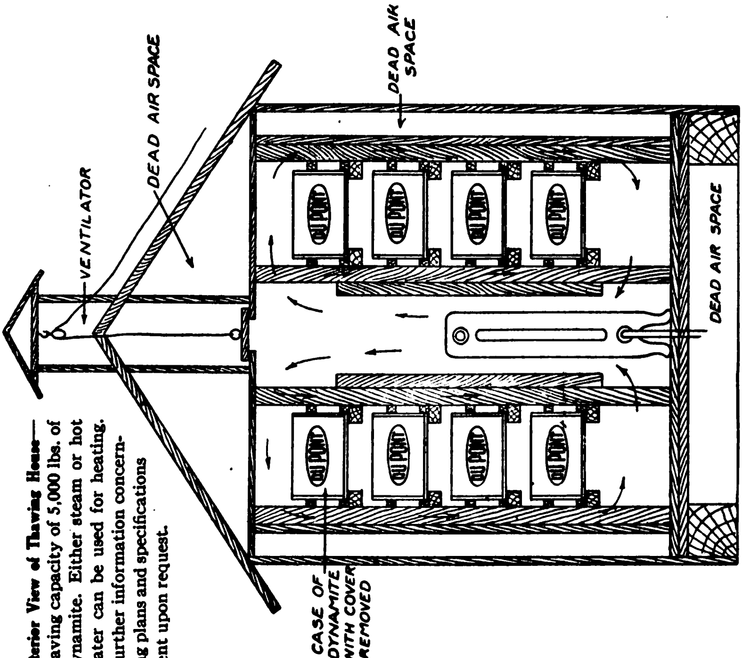
HEATED BY HOT WATER



DYNAMITE THAWING HOUSE HEATED BY HOT WATER

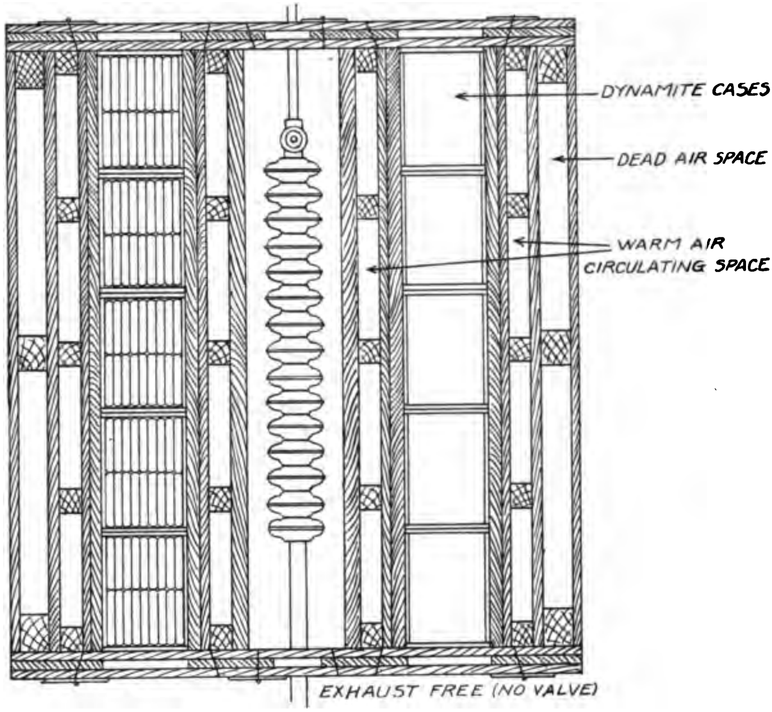


Exterior View of Thawing House—Having capacity of 5,000 lbs. of dynamite. Either steam or hot water can be used for heating. Further information concerning plans and specifications sent upon request.



Interior View of Thawing House—Having capacity of 5,000 lbs. of dynamite. Either steam or hot water can be used for heating. Further information concerning plans and specifications sent upon request.

DYNAMITE THAWING HOUSE HEATED BY EXHAUST STEAM OR HOT WATER



DYNAMITE THAWING HOUSE HEATED BY EXHAUST STEAM OR HOT WATER

dynamite compartments are constructed at both ends, and a door giving access to the heating compartment is constructed at one or both ends.

In operation, the key to the door of the heating compartment is in the hands of the person in charge of the heating arrangements, not of the quarry foreman nor magazine-keeper. The keys to the doors at one end of the dynamite compartments are given into the hands of the magazine-keeper, who, from time to time, slides fresh dynamite cases into the racks, so as to fill the compartments. The foreman of the quarry has the keys to the doors at the opposite end of the thawing house, from which he removes the dynamite cases nearest the end, those which have been longest in the thawing house, and which should be thoroughly thawed. The thermometer is placed in the dynamite compartments in such a way that it can be read without entering the house, and a device provided for regulating the temperature of the dynamite compartments.

In this thawing house, there is no place where a workman could be tempted to make primers, and no chance of the dynamite's being placed directly over the heater. In thawing houses of this type, dynamite may be thawed in the quantities required for modern operations, as, for instance, loading well-drill holes. They have proven successful in a number of large operations.

Using High Explosives

Selection of the Detonator

Advantages of Using Strong Detonators

To obtain the full value of a high explosive charge it should be detonated as quickly and completely as possible. The stronger and sharper the initial shock, the quicker and more thorough will be the detonation of the charge and the greater the amount of work secured from it. On the other hand, if the detonation is slow or incomplete, the force exerted will be less and a larger quantity of explosives will be required to do the work. The effect of a detonator on a charge of high explosives in a bore hole is not infinite but decreases with distance. If a weak detonator is employed, the shock created by it may be so lessened in spreading through a charge that it will produce a relatively slow explosion of the dynamite, or will not reach the farthest removed cartridges at all and hence will produce only partial detonation. Therefore strong detonators, which can be depended upon to produce quick and complete detonation, should always be used.

Again, an imperfect detonation such as may be produced by a weak detonator will cause large volumes of poisonous gases to be evolved. The presence of these gases is a matter of serious consequence when the work is underground, instances having occurred when workmen have been killed by gases from partially detonated or burning explosives. Such detonation increases the size and the duration of the flame, whereas perfect detonation results in a minimum of fumes and of flame—a point of first importance with those explosives intended for use in the presence of inflammable gas or coal dust.

If detonators are used which are too weak to detonate a charge of high explosives, they will cause not only a misfire but frequently the loss of the charge, by generating sufficent heat to ignite it.

In buying detonators it is often advisable to buy stronger ones than are actually needed for the work. The charge which they contain is readily affected by moisture, and, consequently, unless storage conditions are of the best, allowance should be made for this loss of strength in order to insure complete detonation. Blasting caps, being open at one end, are more quickly weakened by dampness than are electric blasting caps.

A strong argument for allowing a fair margin of safety when buying detonators is the very small cost of the detonator in comparison with that of the charge of explosives with which it is used. It is difficult to understand why any one, in order to save a few cents on the price of a hundred detonators, would risk the poor execution of the explosives, the loss of the charge, or a misfire, any one of which would cost several dollars at least, or would risk an accident which might cost not only thousands of dollars but also injury to workmen or loss of life.

The extended study and tests of explosives conducted by the United States Bureau of Mines have clearly demonstrated the economy of using only strong detonators, and we find on page 12, Miners' Circular No. 7, printed in 1914 by the Department of the Interior, Bureau of Mines, the following:

"The cost of detonators in comparison with that of the explosives, and the cost of drilling and preparation of the drill hole, is so small that it seems foolish to buy weak detonators simply because they are a little cheaper than strong detonators. Moreover, weak and unsuitable detonators cause high explosives to give off dangerous gases. All permissible explosives lose strength and sensitiveness with age and improper handling, yet by the use of strong detonators they may be made to explode completely.

"When high explosives are detonated, the stronger and quicker the action of the detonator, the greater will be the shock given the explosive and the more effective will be the explosion. In order to make sure that the charge will exert its greatest force, it should be properly tamped and should be detonated quickly and completely. If the explosion of the detonator is slow or incomplete, more of the explosives will be needed to do the work and larger quantities of poisonous gases will be given out. When the detonation is quickest and most complete, the least flame is produced. A detonator too weak to explode the explosive may produce the most heat and set fire to it and the burning explosives may give out poisonous gases. A weak detonator may be strong enough to cause the explosive to explode and yet not cause an effective explosion. Therefore, the detonators used must be strong enough to detonate the charge completely."

It has been a well-proven fact for some time that No. 6 detonators will get more work out of high explosives, particularly gelatin and extra grades, than No. 5 and smaller sizes. It has also been proven that in large charges, such as those in well-drill holes, four No. 6 detonators distributed at equal distances through the charge will give better execution than two detonators of the same size, and that two will do much better work than one. It has lately come to our notice that better execution can be obtained from Du Pont Gelatin with a No. 8 blasting cap than with a No. 6, this being in work where it is not possible to put more than one detonator in each charge.

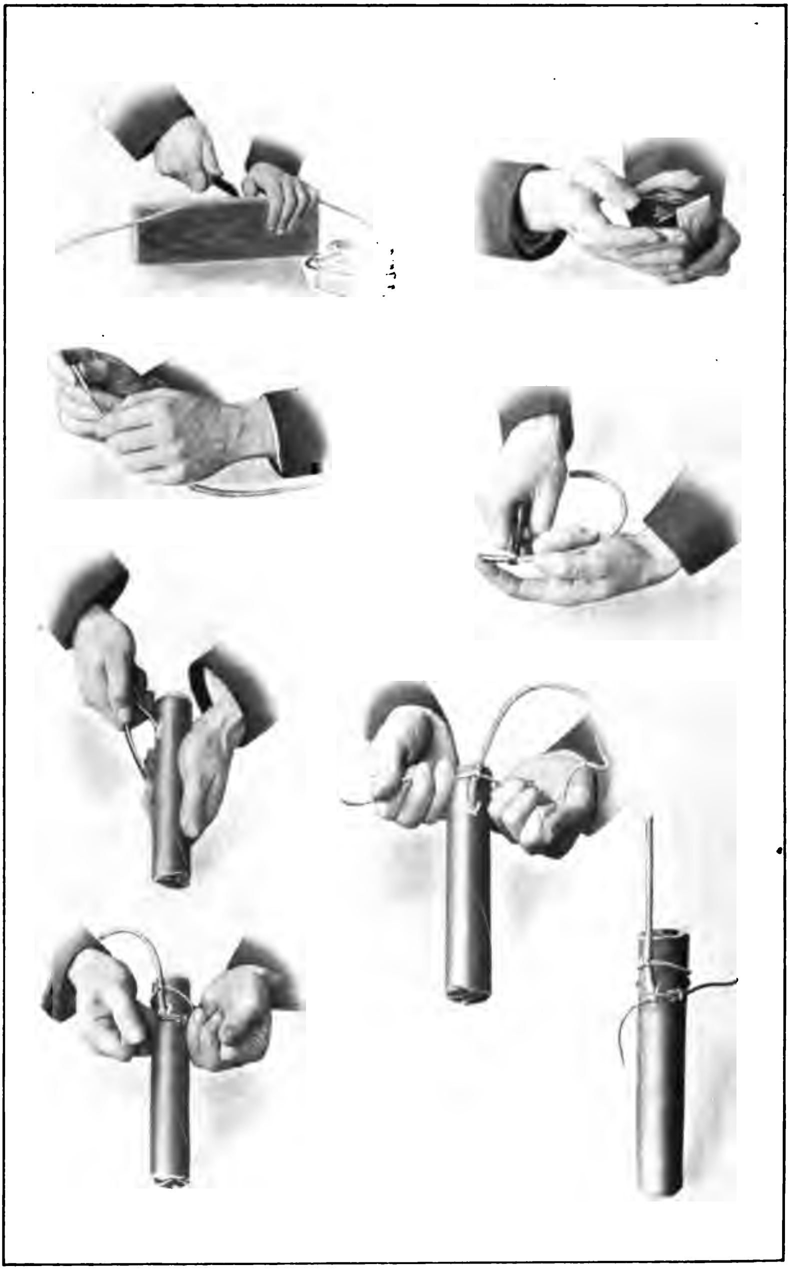
In the western part of the United States, the superintendent of a gold-mining company, engaged in driving a tunnel for developing the property, had been using Du Pont 40 per cent. Gelatin with No. 6 blasting caps. Considering the possibility of better fumes, and possibly more complete detonation, he tried using No. 8 Du Pont Blasting Caps with the same gelatin and found to his surprise and delight that the progress per shift was increased from four to five inches. This increased progress is

worth much more than the increased price of the larger sized blasting caps.

In many tunneling operations the increased distance per round of shots can be had in no other way than by increasing the size of the detonator. The number of drill holes which can be made is limited on account of the time and number of men and machines that can be employed at one time. It is not possible to increase the charges of explosive and it is often not possible to use an explosive of higher grade on account of its being unsuited to the rock. The amount of explosive in each drill hole cannot be increased, as that would necessitate less tamping, which in turn would surely mean blown-out shots. The only remaining resource is to obtain more execution from the explosive. It is probably not possible to develop the entire potential strength of any high explosive; the decomposition, theoretically at least, is always incomplete, but the more nearly the decomposition approaches completeness, the more work is done and the less noxious the character of the fumes. Practically complete decomposition of an explosive, with the production of its maximum disruptive power, can be had only by the greatest possible confinement of the charge, and by the largest and strongest detonator practical for the shot.

Several years ago, during the driving of that portion of the New York subway which ran several hundred feet underground, from One Hundred and Eighty-eighth Street to Fort George, the contractors were straining every nerve to hasten the progress of their work, employing the most expert drillers and blasters, and, though working under difficulties and through an exceedingly hard gneiss, were establishing a record at that time for progress in hard rock tunneling. During the course of the work trouble was encountered at one of the headings from misfires. They were using a 60 per cent. gelatin and what are now known as No. 6 electric blasting caps. In an effort to eliminate the misfires much stronger electric blasting caps were substituted and used for about two weeks. Engineers who were measuring the progress made day by day noticed an increased rate of from six to nine inches during the two weeks that the No. 8 electric blasting caps were used, although the other conditions, as grade of gelatin, number and position of drill holes, amount of explosive per drill hole, and tamping, remained the same. The engineer in charge immediately ordered a supply of the No. 8 electric blasting caps and when told that they would be somewhat more expensive than the No. 6, replied that they would be cheaper for him even if they cost $20 per hundred more than the others, as he was obtaining much more than that value in progress gained in the tunnel.

Where blasting operations are of such a character that the drill holes are overloaded, that is, more explosive put in, or stronger explosive, than is actually necessary to break the rock,



PRIMING WITH BLASTING CAP AND FUSE—FIRST METHOD

it is unlikely that the substitution of stronger detonators will be noticed; but where overloading the drill holes produces less effect, as in tunneling, where a definite amount of tamping is absolutely required to prevent the charges from blowing out, where the rock is hard and tough, and where accurate measurements are possible, it will be found in practically every instance that the substitution of a No. 8 detonator for a No. 6 results in better execution and greater progress.

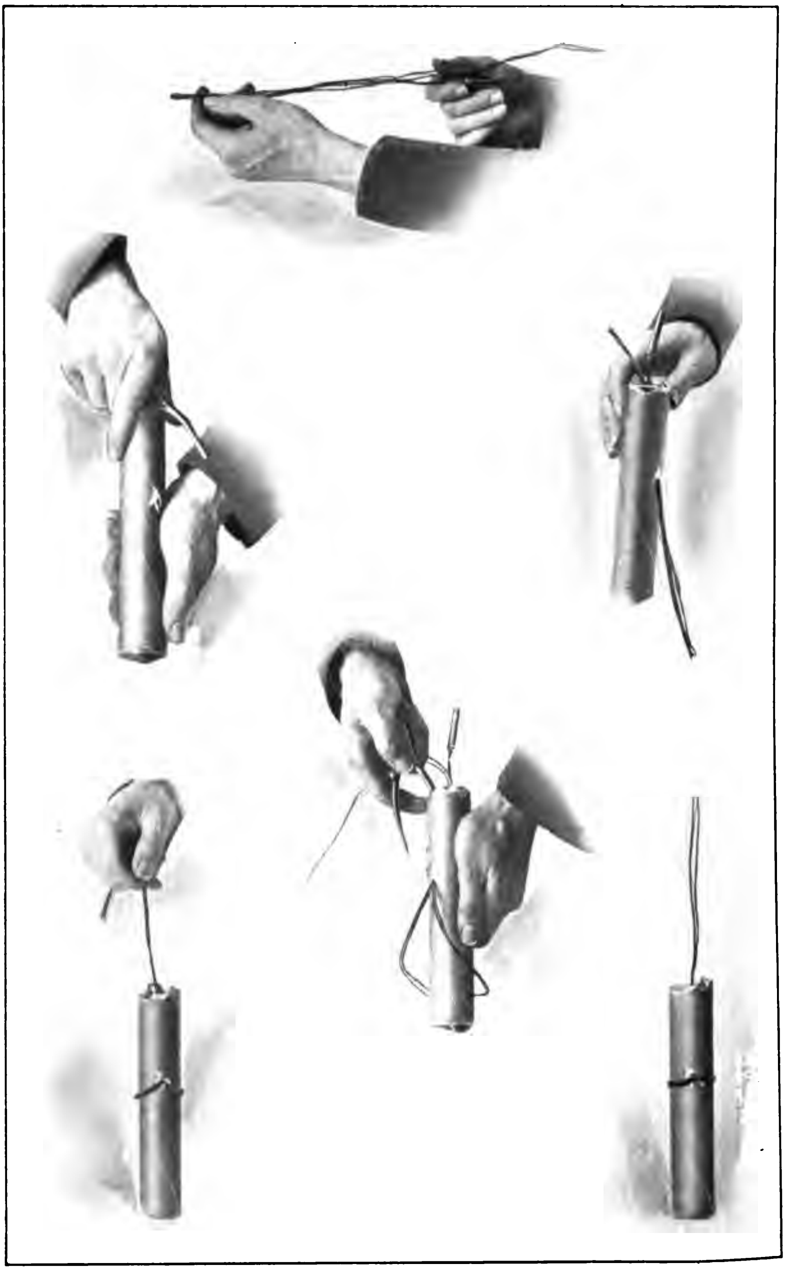
Thus experimental tests and field practice combine to show that strong electric blasting caps or strong blasting caps should be used with all high explosives because:

They insure complete detonation.
They increase the execution of the explosive.
They carry the effect of the detonation farther in long charges.
They reduce fumes to a minimum.
They decrease the size and duration of flame.
They reduce the chances of misfire.
They prevent the loss of the charge by burning.
They offset, to some extent, deterioration due to improper storage.
They tend to counter-balance careless and improper usage.

Advantages of Using Electric Detonators

It will be found also that great advantages are gained if electric detonators are used instead of blasting caps and fuse. In the first place, the electric detonators themselves are superior to blasting caps, in that they are ready for use, do not need to be crimped to the fuse, and thus save time and labor, and preclude the possibility of poor detonation from improper crimping; in that they are more water-resisting and consequently are not so apt to deteriorate and can be used in moisture work; and in that they afford less chance for accidental explosion. But of greatest importance are the manifold advantages to be gained from firing by electricity. In regard to electric blasting, the United States Bureau of Mines says on page 14 of Miners' Circular No. 7, of 1914:

"Electricity is safer, quicker, more efficient, more certain and cheaper than any other means of setting off blasts. Often adjacent shots in the same working face yield the best results in the quantity and quality of the coal produced when they are fired at the same time. This is possible when the shots are fired electrically. For example: In a certain mine using permissible explosives, the yield of lump coal was increased 20 per cent. when the rib holes were all fired by electricity at the same instant. Wet holes can be fired more easily by electricity than by any other method. When electric firing is used the shots can be exploded while the person who is firing the shots is at a safe distance. The explosion follows immediately after the lever or



PRIMING WITH ELECTRIC BLASTING CAP

Second Method

Crimp the blasting cap to the fuse as before. Punch a hole in the end of the dynamite cartridge. Insert a blasting cap. Tie one end of a piece of string around the dynamite cartridge about two inches from the end, firmly, so that it will not slip. Tie the other end of the string to the fuse about an inch above the dynamite cartridge. The strain of the fuse will now come on the string which, if tied tightly at both ends, will not allow the blasting cap to pull out. See page 46.

Priming with Electric Blasting Cap

Either of the above methods may be used for priming with electric blasting caps, if care is taken to tie the string to the wires so that it will not slip.

Another method of priming with an electric blasting cap, but one which is not applicable with blasting cap and fuse, is to punch one hole diagonally from the middle of the end of the cartridge coming out of the side two or three inches down. Straighten out the electric blasting cap wires and then double them, or bend them back about a foot from the capsule, and pass this doubled-up wire through the hole at the top and out at the side of the cartridge. Open the loop of the wire passed through, loop it over the lower end of the cartridge and bring it up around the cartridge. Punch another hole in the end of the cartridge, a half inch away from the first hole and straight down. Insert the capsule of the electric blasting cap in this and take up all slack wire. The cartridge will now hang plumb from the wire, the wires will not cross each other, and the detonator is imbedded in the dynamite, pointing down. See page 48.

The common custom of taking one or more loops, or half hitches, around the cartridge with the wires themselves, after inserting the electric blasting cap in a hole made diagonally in the side of the cartridge near one end, is always to be condemned. The principal objection is that the looping of the wires is very likely to break the insulation, causing short circuit, or leakage of current. Sometimes the wires themselves are broken, or the detonator separated from the cartridge.

There is also danger when an electric blasting cap from 1¼ inches to 2 inches long is pushed into the side of a cartridge 1 inch, 1¼ inches, or even 1½ inches in diameter, that the end of the cap where the principal part of the detonating charge is located will go entirely through the explosive itself even though it may not penetrate the paper shell. As it is often the custom when priming in this way to point the electric blasting cap diagonally toward the end of the cartridge which will be nearest the outside or top of the charge, it can be readily seen that any pull on the wires hard enough to affect the position of the cap will tend to bring it more to a right angle with the long axis of the cartridge, and force its end still farther out of the opposite

FIRST POSITION

SECOND POSITION
DUE TO HARD PULL ON WIRE

INCORRECT METHOD OF INSERTING ELECTRIC BLASTING CAP

side of the cartridge, as shown in the two illustrations on this page. While this does not always cause a failure it is quite possible that many lost shots may be attributed to it, especially when cartridges of small diameters are used.

Proper Time to Prime Cartridges

The practice of making up a supply of primers long before they are to be used is one that should be discouraged by every mine superintendent or foreman. In spare time miners will sometimes make up many more than are needed and keep them several hours or days. While it is often convenient to have the primers made up before beginning loading, it is not as safe as making them at the time, and there has been a number of misfires reported from keeping the primers too long. The cause of these misfires is not fully known, but it is probably due to the nitroglycerin, which is an oil, soaking into the fuse, dissolving and thinning part of the asphalt waterproofing, making it run into the powder core so that the fire will go out when it comes to that place.

All rules for storing and transporting explosives expressly forbid storing or shipping dynamite and caps together on account of the danger of the sensitive and easily exploded caps' setting off the dynamite. Yet primers are simply dynamite and caps put together, exactly the most dangerous combination that there is, and the storing and carrying them around together are often tolerated when storing them in different parts of the same magazine never would be allowed.

When dynamite by itself is set on fire it generally burns up

without exploding, but when cartridges with caps inserted in them get on fire, an explosion invariably results.

Dynamite is sometimes ignited by sparks from miners' lamps, and when no caps are around may do no harm, except to drive everyone out by the noxious and poisonous fumes given off, but when the dynamite is primed it can burn at best only a few seconds and then it explodes; there is no uncertainty about that.

So many accidents have occurred where men have been killed, due to the presence of primed cartridges, and there have been so many narrow escapes from primers' exploding, that there is no excuse for taking a chance of this kind.

Boring the Hole

It is well known that the *location*, *direction*, *size*, and *depth* of the bore hole are important factors in the work done by explosives, and no proficient workman would attempt to locate a bore hole without first making a thorough examination of the structure, presentation, and condition of the material to be blasted. With the comparatively recent advent of many explosives, differing widely in their action, it has been found necessary to adjust the location and pointing of the bore hole to the action of the particular explosive used. In some kinds of work, and particularly in coal mining, it is often necessary in order to secure maximum results to change the location and pointing of the bore holes when changing from one explosive to another. For instance, when blasting undercut bituminous coal with Carbonite or Monobel, the force of the explosive will often spread more and bring down more coal and larger lumps if the bore hole be started 12 to 18 inches from the rib, 2 to 3 feet below the top, and pointed upward so that it will bring up close to the top at the same distance from the rib at which it was started.

Charging

If water is running from the bore hole, load and fire as promptly as possible, and do not slit the cartridges unless gelatin dynamite or blasting gelatin is used. If it is necessary to use Monobel in wet work the bore hole should be swabbed out before loading and the cartridges should never be slit or broken.

A factor of great importance in the action of a charge of explosives is the air space. High explosives used in rock blasting should always be loaded compactly in the bore hole so that no air space remains to act as a cushion when the charge is detonated and so reduce its breaking and rending effect.

The best way to eliminate air spaces is to use dynamite cartridges which are just small enough in diameter to reach the bottom or back of the bore hole without jamming. In addition to using cartridges of the right diameter, it is a good plan to make a slit in the paper shells from end to end with a sharp

knife, unless the work is wet. A cartridge of high explosives, only a little smaller in diameter than the bore hole, and with the shell slit, can be easily spread out with the tamping stick so that it will entirely fill the section of even a somewhat irregular bore hole, and can be relied on to give maximum efficiency when detonated.

This does not apply always in coal blasting where, under certain conditions, in the use of permissible explosives, an "air shot" may give excellent results. In these shots, the air space between the charge and the tamping, with its cushion effect, results in a greater spreading of the pressure developed on detonation. These "air shots" sometimes break across the entire face when the same charge loaded without the air space would blow forward and bring down much less coal.

The cartridge should be pushed firmly and carefully into place with a wooden tamping stick having no metal parts whatever. If the primer is made with fuse and blasting cap it should be put into the bore hole last; if with an electric blasting cap, last or next to last. *Particular care should be taken to insure its close contact with the rest of the charge, and at the same time to avoid moving or shifting the fuse and blasting cap or electric blasting cap from its proper position.*

It might be supposed that the detonator should be placed in the center of the charge in order that its effect be felt throughout. Numerous tests have shown, however, that the greatest effect of a detonator is straight away from its loaded end in a line with its long axis—that is, a detonator will explode a cartridge of dynamite farther away from it if it is lying with the loaded end pointed toward the cartridge than it will if it is lying parallel to or pointed away from the cartridge. In deep bore holes loaded with long charges, it is well to place several electric blasting caps at intervals throughout the charge so that the effect of the detonating compound which they contain will extend the entire length of the charge.

The chances of misfire are greatly reduced by the **use of two or more electric blasting caps in a bore hole.** A missed hole is not only a nuisance and embarrassment, but it wastes time and is a source of danger as long as it remains. Some time ago, one of the leading technical papers invited discussion among its readers on the proper procedure in the case of misfires and it was noticeable that there were very few replies. This is not because misfires are so uncommon that miners and engineers have had no experience with them, but because most blasters are reluctant to admit, especially on paper, what they frequently do with holes which have missed fire. The directions of the explosives manufacturers, the Bureau of Mines and various authorities on the subject of blasting recommend or direct that the bore hole be left undisturbed and that a new hole be bored far enough away from the missed one to be perfectly safe, but

near enough to it so that, when charged and fired, it will explode the charge in the old one. This looks easy enough on paper, but how about the bore hole that takes four or five days to drill, and the bore hole which has been sprung and contains several cases of explosives, the exact position of which is unknown? It is a regrettable fact that a large proportion of men using high explosives, when they encounter a charge which has misfired, forget their directions and take a chance on digging out the tamping, even though they know they are taking their lives in their hands in doing so. It may as well be candidly admitted that in some instances the man with the misfire is strictly "up against it."

Although the cure of a misfire is difficult, uncertain and dangerous, the prevention is easy enough. It is not difficult to load the charge in such a way that should a misfire occur it will be unnecessary either to drill a new hole or to dig out the tamping in the old one. One way, of course, is not to put in any tamping. It is then the easiest thing in the world to insert another primer and try again, but this method is exceedingly expensive, as it is impossible to get the work out of dynamite in holes which are not tamped; in fact, it is necessary to overload them very greatly in order to get even a part of the work.

The other way, *and the right way*, is to place at least two primers in each bore hole. If the number of holes to be fired at one shot is very nearly as great as the number of electric blasting caps that the blasting machine will fire, only one of the primers from each hole is connected up, the other kept in reserve, so that in case of a charge's missing fire, the second electric blasting cap can be connected up and fired. At first thought, this method may appear to be expensive and extravagant, but it is really much less so than it appears, because in the event that all the charges fire at first, it is a proven fact that the second detonator, far from being wasted, really pays more than its cost by increasing the completeness of the detonation of the dynamite, and the amount of work done. Where large charges are loaded in each hole, as in sprung holes, it is customary to place one primer in the pocket and the other in the bore hole, and, if the total number of electric blasting caps used are well within the capacity of the blasting machine, to connect them all up and fire them as if each were in a separate hole. This not only insures the explosion of each charge, but also insures the maximum possible efficiency of the explosive.

The fact that two detonators are able to get more work out of the dynamite than one was shown conclusively in the first blasts made in well-drill holes (holes usually 5 or 6 inches in diameter and 30 to 150 feet deep, drilled by a blast hole drill). The old idea that one detonator is able to explode an indefinite amount of dynamite was shown to be erroneous, as frequently the top of the charge, where the detonator was, would explode

and do good work, while unexploded dynamite would be found in the bottom. When two electric blasting caps were used, one near the top and one near the bottom, complete detonation of the entire charge was assured in moderate sized holes and better work was done than with only one detonator, even when one left no unexploded dynamite. No well-drill holes are fired nowadays with but one electric blasting cap per hole, and not many with only two, for not only does the increased efficiency more than pay for the extra ones, but there is too much money value in explosives in a big well-drill hole to risk any chance of a misfire. Three, four, and even more electric blasting caps are now frequently used in each charge in well-drill holes, and it is not improbable that the popularity that this method of blasting has enjoyed in recent years is due not only to the fact that the explosive is most thoroughly detonated by having several electric blasting caps in it, but also to the freedom from misfires which accompanies this method of loading.

Tamping (Stemming)

Although high explosives, particularly the higher grades, will give considerable local effect, even if fired with little or no confinement (as in "mudcapping" rocks or boulders), they will not give anything like maximum results under such conditions, or even in bore holes that are not thoroughly tamped to the mouth or "collar". Therefore, the only economical way to use explosives is to *fill* the bore hole *entirely* after the charge is in place, with damp clay or similar material packed firmly in place.

In regard to the advantages of confining explosives before firing them, the following is quoted from United States Bureau of Mines Bulletin 423:

"Every explosive, when exploded, exerts pressure in every direction. When laid on top of a rock and exploded, gunpowder and other low explosives do not affect the rock, because they explode so slowly that the gases formed can lift the air above them and escape; but dynamite, fulminate of mercury, and other high explosives, if laid upon brittle or soft rock and detonated, may shatter it, because they explode so quickly that the gases formed cannot lift the large volume of air which confines them, without pressing back forcibly against the rock. This confinement by air is not, however, close enough to give the best result with any explosive. By boring a hole in rock and tamping the explosive firmly in it, gunpowder and other low explosives may be made to break the rock, or a much less quantity of high explosives will break the rock than is required to break it when laid upon it. Confining an explosive is the cheapest and best way to use it."

To tamp a bore hole properly after the charge of explosives is in place, put in two or three inches of damp dirt or damp sand free from pieces of rock (never use fine coal or any other material

that will burn) and tamp lightly. Use an all-wood tamping stick; *it is very dangerous to use metal rods* or sticks with any metal about them for tamping. Pack the tamping material as firmly on the top of the charge as can consistently be done without shifting the blasting cap or electric blasting cap in the primer. Then fill up a few inches more of the bore hole with tamping material, packing it in a little more firmly. After five inches covers the charge, the tamping may be pressed firmly into place without danger of premature explosion. *It is not safe to tamp by a blow any stronger than can be given by hand.* The firmer and harder the tamping is put in (without overlooking the above precautions) the better will be the results. If the bore hole is not properly tamped, the charge is likely to "blow out", or at any rate some of its force will be wasted.

An Easy Way to Obtain Practice in Charging and Tamping Bore Holes

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"The use and abuse of explosives is attracting as much attention if not more than any one subject now being considered by mining men, whether considered from the standpoint of the miner or the operator. Elaborate and costly experimental plants have been installed within a few years by the manufacturers of explosives and by the U. S. Geological Survey at the Pittsburgh Testing Station to determine the properties of the common explosives used in mining and to demonstrate the proper method of using them. The charging and tamping of the holes drilled to break down coal or rock in a mine are matters of interest and importance, but too often these operations are poorly done, due to negligence, carelessness or inexperience. It is impossible to see inside a drill hole that has been charged to determine if the fuse has been broken or kinked, the blasting cap pulled out of the cartridge or to discover the other possible accidents that will occur to every practical man. In order to enable the students in Mining Engineering at the University of Illinois to practice charging bore holes and then have the charge inspected and criticised, a charging box or 'artificial hole' has been built. This is shown on the following page, and consists of a block of timber 8 inches square and 4 feet 6 inches long, with a hole 2 inches in diameter, drilled in the center. This block is sawed through the center, hinged and held firmly by clamps while the hole is being charged. It is then opened and the charge easily inspected. By varnishing and greasing the hole, the tamping is prevented from sticking to the wood when the top is raised. The 'hole' is set on wooden horses and by raising one horse a bore hole inclined upward or downward can be obtained. Students are required to charge the hole, using different kinds of

CHARGING BOX CLOSED AND READY FOR TAMPING OPERATION

CHARGING BOX OPEN TO ENABLE AN EXAMINATION OF LOADING OPERATION

tamping, different explosives, and all of the ways of firing by squib, cap and fuse, and electric detonators. Sand or sawdust is used to represent black powder and dummy cartridges of inexplosive dope to represent the nitroglycerin explosives. The charge is examined and criticised by the class and by the instructor.

"An experienced miner and former mine manager who was showing a class of students how to load the hole was very much surprised to find, upon opening the box, that the fuse was kinked into an S shape and broken.

"By the use of this box the effect of using different kinds of tamping can be easily shown, the rate of burning of fuse in a hole can be tested and other experiments with explosives demonstrated much better than in the darkness of a mine where also the inside of the charged hole cannot be seen.

"A glass tube was first thought of, but the glass breaks readily, is hard to clean from the tamping for another charge and, moreover, as the inside can be seen during the tamping, the actual conditions are not represented nearly as well as with the block.

"The blasting box or hole, which can be easily made and is inexpensive, is adapted for demonstrating to inexperienced men at a mine the proper method of charging. It can also be used for demonstration purposes before mining institutes, etc."

Some Precautions in Using Explosives

In Loading and Tamping

An explosive gives the best return on the investment when the burden is just a little less than its strength. Poor confinement, insufficient tamping, and weak detonators all handicap the explosive—perhaps to the extent of causing a total failure.

To secure maximum confinement, use cartridges of a size that will go to the bottom easily and without being forced. If the standard sized cartridges begin to stick, it is time to look at the drill bit gauge and compare the bits with it. Blacksmiths sometimes become careless about keeping the diameters up to full size. If the hole is dry and not unduly rough, slit the cartridges with a sharp knife (a case knife is best), drop them one at a time in the hole until it rises a couple of feet. Then press down with the tamping stick or lower the tamping block and drop it gently. It does not require a great amount of force to pack dynamite compactly in a bore hole, and it is neither necessary nor desirable to ram it with all your might. In well-drill hole loading, if the hole is full of water it is necessary to use a loaded tamping block, but it is not necessary if the hole is dry.

It is usually undesirable to slit the cartridges if the bore hole is very wet. The water fills the air spaces and is detrimental to the powder—unless it is a gelatin. If there are only a few feet of water in the bore hole, load unslit cartridges until they rise above the water. In dry holes and above the water level, slit each cartridge once or twice, but do not twist the cartridge,

as that exposes the powder and allows it to be smeared along the sides, where it does no good and may give trouble.

If the holes are drilled through loose rock or top soil, it is a good thing to make a pit at the point where the hole is started, that is, to remove the loose material so that it will not fall down into the hole and make trouble.

In very deep well-drill holes, the first few cartridges may be lowered on a string tied to a wooden peg or skewer which is jerked free after the cartridges reach the bottom. There is then a cushion on which the other cartridges may be dropped instead of on the hard rock. Water, of course, is cushion enough. A tripod, eight or so feet high, with a snatch block suspended from it, placed over the hole, makes tamping easier and safer in well-drill holes where a rope and block are used in place of a tamping stick. It also keeps the men who work the rope away from the hole. A precaution worth while in well-drill hole loading is to compel the men who compose the loading gang to take all matches and metallic objects out of their pockets while at work, being particularly careful about blasting caps. If any of the gang have occasion to do block-hole or mudcap shooting at any time, they may keep a few blasting caps in their overall pockets and if one of these should fall down a big hole while being loaded, there would be a very great likelihood of a bad accident.

With short holes, tripod drill holes, and the like, do not use too heavy a tamping stick. A husky man ramming dynamite with an oak pole 20 feet long and 2 inches in diameter is not a reassuring object. Pine or spruce is heavy enough. A bamboo fishing pole makes a good tamping stick for some work, is cheap, easily procured, and straight—all desirable attributes, but particularly, it is light and is not as effective a battering ram as oak or hickory.

In "lifters" or holes drilled horizontally or nearly so, and particularly when they are "sprung", a tube of zinc as large in diameter as will go in the hole and long enough to reach to the bottom will prevent the dynamite cartridges from jamming in the hole. If the loading tube is not used the cartridges may be impaled on the small end of the bamboo pole and carried to the pocket or to the end of the hole. Do not slit cartridges used in sprung holes in hard rock. Many accidents have occurred in this work which could be explained only on the ground that particles of dynamite had been punched, squeezed, or rubbed between loose rocks.

Don't open the dynamite cases with a steel chisel or a rock. Use a wooden mallet and a wooden wedge.

In Firing

When blasting by electricity, test the circuit with a Du Pont galvanometer before firing, and, on important blasts, test the

electric blasting caps separately also. Test the blasting machine with a Du Pont rheostat to make sure that it is up to capacity. Test each hole before the sand or clay tamping is put in so that another primer may be added in case a wire is broken.

In firing with cap and fuse, it is especially advisable to **avoid using short fuse.** In order that the charge may be thoroughly tamped and confined and the whole of the explosive power thereby realized, and in order that the blaster may be safely out of the way before the charge explodes, the fuse must be long enough to extend from the charge to the collar of the drill hole and far enough out of the hole to allow time for the blaster to get to a place of safety after lighting the fuse.

It is the reprehensible practice of some miners to cut the fuse attached to the cartridge so short that it will not extend out of the hole—only six or nine inches, or possibly a foot, long. They light the fuse, and, while it is sputtering, ram the cartridge into the bore hole, and "run like the deuce". They may, sometimes, throw in a light tamping, but their time is too short to tamp the charge thoroughly, as they realize that the locality is distinctly unhealthy for the time being.

Why do they do it? To save fuse which costs anywhere from a third of a cent to a cent a foot.

By using a foot of fuse instead of three or four feet, they save from one to three cents' worth of fuse, but they waste as much or more than this in the value of the dynamite, because from lack of proper confinement and tamping only a part of the explosive power of the dynamite is realized. Then, too, the danger of this operation is very great. In the open and unconfined, a foot of fuse of American manufacture takes about thirty seconds to burn, but, in the bore hole, even though tamped hurriedly and incompletely, it is likely to burn faster than that. Consequently, the race between the fuse and the blaster is so close that he runs a great risk of being caught by the blast.

Of what advantage is it to the miner to save a few cents a day on fuse while he is losing several cents a day on wasted dynamite? Furthermore, even though he could save these few cents, of what advantage would it be to him, if he should be eventually killed or injured?

This practice of using short fuse is wasteful of explosives, dangerous, and in the end is likely to be very expensive to the miner or to his family.

DESTRUCTION OF GAMBOA DIKE ON PANAMA CANAL

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The Uses of High Explosives

Many varied kinds of work are carried on with explosives and it is very important that the user of explosives buy the one best suited to the work to be done. In order to do this, he must consider the characteristics of the explosive. The qualities with which he is most concerned are strength, quickness, sensitiveness, resistance to cold, resistance to water, and the nature of the fumes evolved. These vary in importance according to the kind of work, the qualities most desirable in one kind of work being, perhaps, of little value or actually harmful in another. It is a great mistake for the consumer to buy explosives regardless of their special characteristics and without knowing positively just what kind of explosive would be most economical for his particular purpose.

A large proportion of the complaints arising from the supposed failure of explosives to do the work desired is due, not to any inherent defect in the explosive itself, but to the fact that it is not suited to the class of work for which it is used. The use of a high-grade gelatin for mudcapping, of explosives of the permissible type for open work, and other kinds of quick, shattering explosives for soil and close work, and of slow acting explosives in brittle rock are examples of what may be termed "explosives misfits."

The gelatin explosives are not quick acting enough for mudcapping. Permissibles are designed primarily for coal mining and produce a relatively low temperature, a flame of short duration, and a very small amount of objectionable smoke or fumes. Some explosives are made so as to be as strong and quick as possible without regard to their fumes. A particular kind of rock may resist the action of a quick powder, while a slow acting powder in it would give the desired results. No one explosive can be made which combines the desirable properties of all of them, although some varieties have a wider range of application than others.

It is, of course, not expected that the consumer should be fully conversant with the exact properties of each of the many kinds of high explosives which we manufacture. We maintain a corps of experts in the use of explosives for the purpose of furnishing him with the necessary information. We are glad to send these experts, upon request, to look over the work of our customers and to advise them as to what explosives should be used and the most economical manner of using them.

Coal Mining

In comparatively dry coal mines where neither gas nor dust occurs in dangerous quantities, blasting powder is largely used. Where gas and dust exist it is a mistake to use any blasting

agent other than a permissible explosive. The permissible explosives are those which have been tested by the United States Government and recommended for blasting in gaseous and dusty coal mines. If used according to instructions these explosives should not ignite mine gas or coal dust.

Excepting in very wet work Monobel and Duobel are the best explosives to use in gaseous or dusty coal mines. Monobel is made in six grades: No. 1, No. 2, No. 3, No. 4, No. 5, and No. 6. Duobel, in one grade.

Monobel No. 1 and Monobel No. 6 are the quickest, Monobel No. 2 and Monobel No. 4 next. These grades are adapted for hard shooting anthracite coal or bituminous coal which is intended for coking and should be well broken up. Monobel No. 3 and Monobel No. 5 are very slow, and if properly used will not break up the softest and most friable coal any more than will blasting powder.

If in cold weather the cartridge in which the detonator is to be placed is hard, the end can be crumbled with the fingers so that the detonator can be easily inserted.

Monobel No. 4, Monobel No. 5, and Monobel No. 6 will remain unfrozen at temperatures which freeze the other grades. Unless the work be quite dry, it is best not to slit Monobel cartridges. Monobel usually has more of a spreading effect and is less shattering if the cartridges do not completely fill the back of the bore hole and an air space be left around them, because this

THE RESULT OF A SHOT AFTER CORRECTLY LOADING MONOBEL PERMISSIBLE EXPLOSIVES

air space acts as a cushion when the Monobel is detonated. When blasting in this way it is a good plan to use cartridges considerably smaller in diameter than the bore hole—say a 1¼-inch cartridge in a bore hole that would take a 1½-inch cartridge, or a 1½-inch cartridge in a bore hole that would take a 1¾-inch cartridge. Conditions met with in blasting coal differ greatly, and as it is necessary to accommodate the location, direction, and depth of bore holes to these conditions, it is impossible to give any general rule in regard to them.

Duobel has all the physical characteristics of the Monobels, but, owing to its lower density, it distributes the blow of the explosion over a greater area than does an equal weight of Monobel. Because of this characteristic, it works exceedingly well in almost any kind of coal. Merely varying the amount used governs the fragmentation. One property of Duobel which makes it very valuable in mines with poor ventilation and desirable in all mines is that it gives off very little smoke. Many miners refer to it as "that Smokeless Powder." A case of Duobel contains about 155 cartridges, size 1¼ x 8 inches, so that the cost per cartridge is relatively very low.

When coal mining is *very wet* and a permissible explosive is necessary, blasting should be done with one of the Carbonites. Unless the work is exceptionally wet there is no disadvantage in slitting the Carbonite cartridges if the shot is fired immediately after the bore hole is charged and tamped. Carbonite No. 1, No. 2 and No. 3 freeze at temperatures between 45° F. and 50° F., and cannot be properly detonated unless they are thoroughly thawed. Carbonite No. 6 is the low-freezing grade and is not readily affected by cold. Carbonite No. 1 is the most shattering. Carbonite No. 6 and No. 3, which correspond to each other in action, are much less shattering than No. 1, while No. 2 ranks between No. 1 and Nos. 6 and 3.

Stripping

The removal of the surface from beds of ore or coal, commonly called stripping, does not differ materially from other large excavating work, and explosives are used for stripping in much the same way as they are in railroad construction, quarrying, and such work.

It is usually the custom in stripping work to drill holes from 16 to 20 feet deep, spring or chamber these with from ten to thirty pounds of from 30 per cent. to 40 per cent. Red Cross Extra Dynamite and then charge, if the work is dry, with from four to twelve kegs of blasting powder, or if the work is damp, with the same number of 12½-pound bags of Du Pont R. R. P. If the work is wet, Red Cross Straight Dynamite will give best results.

Sometimes, when the material to be moved is earth or shaly rock, tunnels just large enough for a man to crawl into are

EXPLOSIVES PLAY A VERY IMPORTANT PART IN THE CONSTRUCTION OF RAILROADS

driven into the bottom of the face, and large charges of blasting powder or Du Pont R. R. P. are placed in cross cuts or chambers at the inner ends of these tunnels. Occasionally cross cuts are driven half way back and charges of explosives located there also. The tunnel is filled up completely in front of the charges with earth packed in as tightly as possible. These charges are fired electrically, nitroglycerin dynamite being used for a primer. This system of blasting is known as "gopher holing". A similar plan with larger tunnels and headings is also practiced occasionally in ballast quarries and very heavy railroad cuts.

It is frequently necessary to resort to blockholing or mudcapping in stripping operations. These methods are described in the section "Quarrying".

Railroad Construction

Many kinds of blasting are necessary in railroad construction, and accordingly different explosives must be selected, and they must be used in different ways. In open cut work it is generally best, when in rock, to use dynamite of from 30 per cent. to 60 per cent. strength, depending on the hardness of the rock. To blast in clay or shale, use Du Pont R. R P., or blasting powder after the holes have been chambered or sprung with 40 per cent. dynamite. If the work is wet use Red Cross Straight Dynamite, but if very wet use Red Cross Gelatin.

Red Cross Straight Dynamite is best for mudcapping or blistering.

Proper location and depth for bore holes in this kind of work can be determined only by careful examination and study of conditions.

Canal Digging

Conditions met with when digging canals are generally similar to those encountered in railroad construction. The suggestions in regard to the use of explosives in railroad construction may, therefore, be applied to canal digging.

Tunnel Driving

The best explosive to use and the proper location and pointing of bore holes in tunnel driving are dependent on the size and shape of the tunnel and the kind of rock encountered. Large tunnels are driven in two horizontal sections, the upper one being known as the heading and the lower as the bench. The heading is practically a smaller tunnel and is driven in the same way as a tunnel of that size would be, while the bench is shot down with charges placed in vertical holes drilled back of the face or lifted up with charges in horizontal holes drilled into the bottom of the face.

DRILLING MACHINE AT WORK IN ARIZONA COPPER MINE

Small tunnels, and headings in large ones, are usually drilled so that a vertical wedge can first be blasted out of the middle of the face. Relief holes which widen and square up this wedge are next shot and then the blasting of rib or side holes and top holes and bottom holes brings the tunnel to the proper size.

In ordinary rock from 50 per cent. to 60 per cent. gelatin dynamite should be used, while very hard rock will be broken up better if blasting gelatin makes up part of the charge in the cut and relief hole.

Quarrying

Blasting powder is generally used for blasting dimension stone, but satisfactory results can often be had by using light charges of from 20 per cent. to 30 per cent. Red Cross Extra Dynamite, in cartridges considerably smaller in diameter than the bore hole. In this work particular care should be taken to leave a considerable air space between the charge and the sides of the bore hole. If the work is very wet, use 25 per cent. or 30 per cent. Red Cross Straight Dynamite.

In quarries producing ballast, cement rock, limestone, or other material which should be well broken up, 40 per cent. dynamite is the best explosive to use, unless the rock is exceptionally hard or the work very wet. Under these conditions 50 or 60 per cent. dynamite should be used. In deep bore holes where the rock is not very hard, Du Pont R. R. P. has given excellent results. It is sometimes of great advantage to use some blasting gelatin in the bottom of deep bore holes in hard rock, or in that part of the bore hole which penetrates the hardest stratum. Bore holes (excepting well-drill holes) are usually located from 6 to 10 feet back of the face, spaced from 5 to 8 feet apart and drilled from 6 to 20 feet deep, according to the nature of the rock and other conditions. If a double row of holes is drilled so that they will be alternated or "staggered" and all are fired at once, the material will be broken up considerably better than with a single row.

In quarries or other work where fissures or seams occur in the rock, considerable drilling can be saved by taking advantage of these seams and loading the explosives into them. It is usually necessary to open up the seam first by firing a small charge of explosives in it. To do this the wrapper or shell should be removed from the cartridge and the explosive pressed as far as possible into the seam with a flat stick. This charge is primed by pushing the blasting cap (which has already been crimped to the necessary length of fuse) into the charge with the flat stick. Tamping may or may not be used.

Quarrying is carried on by several different methods. The position of the quarry face, the nature of the material and other conditions varying with the quarry must obviously be determining factors in selecting the best method.

USING 1500 POUNDS OF DU PONT EXPLOSIVES IN A QUARRY IN OHIO RESULTED IN OBTAINING OVER 10,000 TONS OF STONE

ANOTHER VIEW OF THE RESULTS OBTAINED BY USING 1500 POUNDS OF DU PONT EXPLOSIVES IN THE OHIO QUARRY PICTURED AT TOP OF PAGE

Well-Drilling

Well drilling, or the boring of holes by means of a well drill, is often found to be a very desirable method. The well-drill machine was originally designed for oil-well and water-well drilling, and is capable therefore of sinking a hole to a depth exceeding 2,000 feet. Well-drill holes for blasting, however, are not often more than about 150 feet in depth or less than 30 feet.

The well driller is a self-contained machine, usually with its own steam or gasoline engine on wheels, sometimes able to move from place to place by its own power. The drilling is accomplished by lifting a heavy cutting bit, weighing 1,000 pounds or more, and dropping it on the rock, the engine or motor being of such size as to make possible about fifty or sixty blows per minute. This is quite different from the ordinary air or steam tripod drill, where a comparatively light bit is driven by steam or air pressure against a rock. With the tripod drills, the depth of the hole is limited by the length of the bit and it is not usually economical to have the bit longer than 25 or 30 feet in length. With the well-drill machine, the bit is suspended by a rope or cable, so that the drilling bit is the same size for any depth hole desired, the deeper the holes the more rope being paid out from the machine.

Well drilling has many advantages over tripod drilling. A well-drill hole can be put down the entire depth of the quarry face. It can be made of such a size as to contain very large charges of explosive without springing. The well-drill machine can run when operated by steam or gasoline after the main power plant and air pressure are shut down for the winter. On account of the larger diameter of well-drill holes, it is possible to place them farther apart and farther back from the face than is possible with the tripod drill, and to bring down a very much larger quantity of rock. It is not always necessary to strip the earth from the top of the rock with the well-drill machine as it is with the tripod drill, and there is a considerable element of safety in not having a high face of rock worked off in benches, with the men cleaning the benches and endangering the loaders below by falling rock.

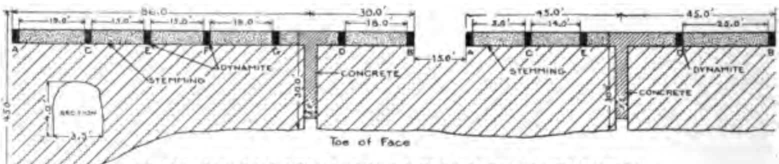
On the other hand, the tripod drill is much more easily moved from place to place, can be easily put up on irregular places, and can drill a hole in any direction—up, straight in, slanting downwards or straight downwards, whereas the well-drill machine is limited to one position only, which is straight down.

Blasting in well-drill holes doubtless effects a considerable saving in explosive, at least for the initial blast. The amount of secondary blasting, such as mudcapping and blockholing, necessary after a widely spaced well-drill blast will depend on the character and stratification of the rock, the purpose for which the rock is used, and the size of the equipment for handling it. Some quarries are not adapted for well-drill blasting, either on

account of the angle of the stratification or the nearness of the quarry face to other property. In the latter case, there is danger of flying fragments' causing damages, but this may be prevented by intelligent spacing and loading of the holes.

Tunnel Blasting

One of the most economical methods of blasting rock is that known in the East as the tunnel blast and in the West as the gopher hole. The amount of explosive used in each blast is very large, and it is necessary to use the utmost care not only in regard to the selection of the explosive, the quantity used, and the placing of the charge, but also in regard to the electrical connections. These must be frequently and thoroughly tested during loading, so that there is no possibility of a misfire.



SHOWING LOCATION OF EXPLOSIVES IN TUNNELS DESCRIBED BELOW

A most successful tunnel blast was recently made, in a large limestone quarry, in the following manner: Two tunnels were driven straight into the face of the rock, 30 feet long, about 3 feet wide and 4 feet high. Branches were made at right angles, both ways from the end of each tunnel, of the same height and width as the main tunnels, three of them being driven from 30 to 40 feet in length and the other about 90 feet. The explosive was loaded in the cross-cuts in twelve divisions of from 1,000 to 2,000 pounds each, no explosive being placed in the main tunnels. The charges were placed from 15 to 20 feet apart, and the intervening spaces filled with broken rock, sand, muck, and dirt. The main tunnels were filled up solid with concrete. The explosive charges consisted of about equal parts of Du Pont Straight 60 per cent. strength and Du Pont R. R. P. Three electric blasting caps were placed in each charge, in the 60 per cent. dynamite. They were all connected in parallel to large-sized leading wires carried into the cross-cuts. About 15,000 pounds of explosive, costing $1,376.25, brought down approximately 50,000 cubic yards of rock, at a cost of about 2¾ cents per cubic yard. The firing was done with a power circuit delivering a 30-ampere current at 110 volts. The cost of driving the 266 feet of tunnel was about $400. The rock was broken up so well that very little subsequent blasting was required to get it into the size desired.

Tunnel blasting is not well adapted for work in those quarries -here the rock is of such character that the tunnel roof will not ld up without timbering, as this increases the cost too much;

neither is it recommended in quarries situated in populous districts, not on account of the concussion, but because hidden fault in the rock might result in the rock being thrown so far as to cause damage.

Secondary Blasting

Rock which has been blasted out in blocks too large to handle is broken up by blockholing or by mudcapping (sometimes called blistering, bulldozing, or doby shooting). Blockholing saves explosives and mudcapping saves drilling and time. In blockholing, a hole is drilled into the rock deep enough to hold the requisite quantity of explosives and tamping. The amount of explosives necessary depends entirely on the size, shape, and quality of the stone to be broken. Usually 1″ x 8″ cartridges are used for this class of work. This charge can be detonated with either an electric blasting cap or a blasting cap and fuse. Red Cross Extra Dynamite of from 20 to 40 per cent. strength is recommended for this work.

In mudcapping, the charge may range between a half cartridge and several pounds, according to the size, shape, structure, and hardness of the stone. The cartridges should be slit and packed in a mass as close to the surface of the stone as possible, on a flat or hollow side of the stone, and if practicable, in such a position that the force of the explosive will be exerted along the cleavage and at a right angle to the stratification. The charge should then be covered with a mass of stiff clay pressed down as firmly as possible. The best explosives for mudcapping stone are from 40 per cent. to 60 per cent. Red Cross Straight Dynamite.

A special book on quarrying, "Du Pont Explosives for Quarrying," will be sent free on request.

Clay Blasting

The use of explosives in clay blasting has excited much interest among clay producers and a portion of "Du Pont Explosives for Quarrying" is devoted to this subject.

Ore Mining

The varying formations of rock and degrees of hardness make necessary different methods of blasting ore. Mining underground is done by "stoping" or by "slicing and caving", and mining in the open, by stripping off the surface and taking out the ore. In underground work holes are drilled from 3 to 6 or 7 feet in depth, according to the hardness of the ore and the size of the stope or drift. In some places a vertical and in others a horizontal "cut" is blasted out of the face first and the necessary squaring up shots are fired afterward.

If the ore is unusually hard and the work very wet, the explosive should be gelatin dynamite of from 60 per cent. to 80 per

FACE OF A DRIFT IN AN ORE MINE SHOWING LOCATION OF EXPLOSIVE CHARGES READY FOR DETONATING

cent. strength, or blasting gelatin. These should be exploded with No. 6 (red label) or stronger detonators. If the ore is not unusually hard, use from 35 per cent. to 60 per cent. gelatin dynamite. In comparatively dry mines Red Cross Extra Dynamite is especially recommended because of its low freezing properties. In open ore mining bore holes should be chambered or sprung with 30 per cent. or 60 per per cent. dynamite and then charged with blasting powder or Du Pont R. R. P., according to the character of the ore and location of the bore holes. Blasting powder is not satisfactory in wet work.

Road Construction

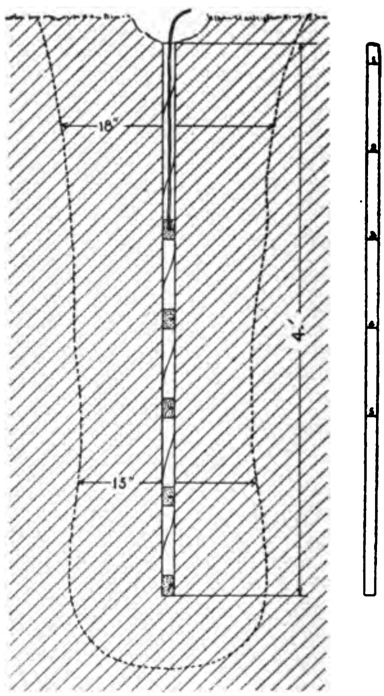
We have issued a special book, "Road Construction and Maintenance", which not only covers thoroughly the use of explosives in road building but forms a quite comprehensive text-book on the whole subject of road construction. A copy of this book will be sent on request.

DRILLING HOLES IN THE BREAST IN A GOLD MINE PREPARATORY TO BLASTING

Blasting Telegraph and Telephone Pole Holes

A new method has been developed for digging holes with dynamite for planting telegraph and telephone poles. The original method was to clear away about 6 inches in depth of the earth at the surface, bore a hole with an auger to the required depth, and fire a small charge of dynamite in the bottom with blasting cap and fuse. A modification of this method was to fire new charges, making the first blast at half the required depth, and the second blast at the depth desired. A new method, which does not require as much cleaning out as the older method, is to fire one or more cartridges of dynamite cut up in halves, thirds, or quarters and spaced at even intervals in the bore hole. The firing may be done by means of a blasting cap and fuse, or an electric blasting cap and battery, the detonator in either case being placed in the top cartridge. This fires all the sections of dynamite by the concussion traveling from one section to another, producing, when properly spaced and loaded, a hole of the required depth and diameter, with no subsequent digging out. Where no water is encountered, Red Cross Extra 40 per cent. strength is the explosive recommended. In wet land and where the holes are likely to contain water, either Red Cross Straight 40 per cent. or Du Pont Straight 40 per cent. will give excellent results, although the latter requires thawing in cold weather.

The dynamite method for digging telephone and telegraph pole holes not only costs less than hand digging, but it is much quicker, especially in hard soil. The sections of dynamite cartridges may be spaced either by pinning them in the proper places in a tube of heavy paper made as long as the proposed auger hole and of a diameter which will easily inclose the dynamite cartridges, or by binding them to a flat strip of thin wood, such as bamboo. Old porch screens make excellent material for this purpose. Electricians' adhesive tape or insulated tape is used for fastening the parts of the dynamite cartridges at the desired intervals along the



SHOWING HOW DISTRIBUTION OF CARTRIDGES IS MADE FOR BLASTING A DEEP POLE HOLE

bamboo strips. This method is somewhat superior to the paper tube in that it does not break in high winds, but it requires more care in loading to keep pieces of loose earth and sand from getting between the sections of the dynamite.

A special booklet entitled "Blasting Pole and Post Holes" will be sent on request. This booklet has been prepared with great care and will be found of great value to every one interested in road work.

Farming

The subject of the use of explosives in agriculture—for stump and boulder blasting, tree planting, orchard rejuvenation, subsoiling, drainage, and ditching—is so large that no attempt has been made to describe it in this book. The subject is treated at length in the "Farmers' Hand Book of Explosives," sent free on request.

Sinking Wells

Wells are generally sunk through rock or ground which cannot be dug to advantage without the aid of explosives. In well sinking when rock is reached and the earth or sand above is properly supported, a circle of four or five drill holes should be started about half-way between the center and the sides of the well and pointed at such an angle that they will come closer together near the center when they are 3 or 4 feet deep. These holes should be loaded about half full of Red Cross Extra Dynamite 40 per cent. with damp clay or sand tamping packed firmly above to the top of the hole and then exploded all together from the surface by electricity. The result of this shot will be to blow out a funnel-shaped opening in the center, and the bottom can then be squared up with another circle of holes drilled straight down as close to the sides as possible. If the well is large it may be necessary to drill a circle of holes between the inner and outer circle. The above process should be repeated until the well has passed through the rock or has been sunk to the necessary depth. Do not in any case enter a well until all the fumes of the last blast have come out. If in doubt, lower a lighted candle to the bottom; if it continues to burn, the well may be entered safely.

Submarine Excavating

When blasting ledges and other rock in the bottoms of harbors and streams, it is generally the custom to use drill boats equipped with steam or air drills unless there is not sufficient work to warrant the installation of such an equipment. In that case it is customary to have divers fasten "torpedoes" or bundles of high explosive cartridges on or under abutting points or reefs, these "torpedoes" being afterward exploded by electricity. It is usually necessary to repeat this process several times before there will be much effect on the ledge, and accordingly this

EXPLOSIVES CAN BE USED VERY EFFECTIVELY FOR DEMOLITION OF CONCRETE WALLS AND FOUNDATIONS

FOR REMOVAL OF FOUNDATIONS, ARCHES AND OTHER CEMENT FORMS, EXPLOSIVES ARE RAPID AND ECONOMIC AIDS

method of submarine blasting cannot be considered economical, and should be resorted to only when necessary.

The usual and best way to use a high explosive under water is to load it in holes drilled from stagings or drill boats. Drilling is generally done through pipes or tubing from 4 to 8 inches in diameter, the purpose of this tubing being to steady the drill and keep it in position. In order to secure the same results under water as would be had on land it is necessary to locate the bore holes closer together and charge them more heavily, as the weight of the water tends to counteract the effect of the explosive.

Submarine bore holes in deep water should be charged by divers. Charging in comparatively shallow water may be done from the surface of the water through the tubing with a long tamping stick or by means of an implement known as a "charger", which is especially designed for the purpose. When working close to wharves or vessels, bore holes should be drilled closer together and light charges used to prevent damage. Submarine firing should always be done electrically, as even the best fuse is not certain after having been under water a little while. Electric blasting caps especially designed for submarine work are the surest and Du Pont Submarine Caps are recommended. To allow the proper margin of safety it is advisable to use the No. 8 strength of these electric blasting caps. The proper explosive to use for submarine blasting is gelatin dynamite, from 40 per cent. to 75 per cent., or if the rock is extraordinarily hard, blasting gelatin. These explosives can be put up, if so desired, in cartridges up to 5 inches in diameter, and 32 or 36 inches long. The paper shells of these cartridges are extra heavy.

Destroying Wrecks

Wrecks of wooden or steel vessels can be completely broken up by high explosives. The charges must be placed by divers and anchored in position if water currents are strong. Firing must be done electrically. Sunken masts may be cut off under water by lowering a ring of high explosives, made by tying cartridges to a properly weighted wooden or iron hoop, down over the top of the mast to the required distance and firing electrically. Gelatin dynamite will give best results in this work.

Starting Log Jams

To start log jams with dynamite the charge of several cartridges or in some instances of many pounds of dynamite is exploded on or under the logs forming the key of the jam. When small charges are enough, the cartridges are tied in a bundle as when blasting ice. If charges of fifty pounds or more are necessary the dynamite may be put in a bag or left in the original wooden cases. The charge is primed with a Du Pont Waterproof Electric Blasting Cap and, after being firmly secured in the

ICE JAMS ARE THE CAUSE OF MUCH DAMAGE WHICH CAN BE PREVENTED BY THE PROPER USE OF EXPLOSIVES TO SHATTER THE FLOES AND JAMS

proper position, is exploded from the shore with a blasting machine.

When logs in rollways have been bound together by the freezing of rain or snow, the block may be broken up by exploding charges of dynamite in different places under the logs until they are loosened and can be rolled apart.

Red Cross Extra Dynamite 40 per cent. is recommended for starting log jams and for opening the rollways.

Blasting Ice

Ice gorges may often be prevented by shattering the large floating cakes with Red Cross Extra Dynamite 40 per cent. so that they will not lodge at dams or in the narrow parts of the stream. To break these cakes several cartridges of the dynamite tied together in a bundle are laid on the ice and exploded. This is repeated until the cake is thoroughly shattered. The size of the charge and the number of times the blasting must be repeated depend altogether on the thickness of the ice and the size of the cake. One cartridge of the bundle is primed with blasting cap and fuse, but before this the dynamite must be thoroughly thawed and kept thawed until it is laid on the ice. This blasting can be done best along broad, slow-moving parts of the stream where it is easy to get onto the ice cakes either from the shore or from boats. When the streams are narrow the charges of dynamite may be thrown on to the ice from the shores, or, if the ice is running swiftly, they may be dropped onto the cakes from the downstream side of bridges. When the charges consisting of two or more cartridges tied together in a bundle are to be thrown onto the floating ice either from bridges or from the shore, a block of wood, a piece of board, or something of that kind should be tied to the charge to keep it from rolling out of position after it lands on the ice. As it is necessary when blasting ice in this way to light the fuse while the dynamite is in the hands of the blaster, particular attention must be given to having the fuse plenty long enough and to throw the charge just as soon as the fuse is lighted.

The following table gives the approximate quantity per charge of Red Cross Extra Dynamite 40 per cent. required to break floating ice cakes of different thicknesses when the dynamite is exploded on the surface of the ice. The number of charges necessary depends on the extent of the ice cake.

Thickness of Ice Cake	Approximate No. of 1¼" x 8" Cartridges
12 inches	2 to 3
24 inches	6 to 8
36 inches	10 to 12

To open ice gorges already formed, a channel should be cut through them beginning on the downstream side and working up

LARGE CASTINGS, BOILERS AND TANKS CAN BE BROKEN BY THE USE OF EXPLOSIVES

LOG JAMS ARE REMOVED WITH THE AID OF EXPLOSIVES

stream along the line of the strongest current. In large streams this channel should be about 50 feet wide, and if the gorge does not move after the channel has been cut through it will then be necessary to begin at the downstream side of the gorge again and widen the channel until the ice has been carried away.

To make the channel, holes are cut through the ice with an ax, bar, or ice spade, from 20 to 30 feet apart. These holes are laid out in a semi-circle with the two end holes from about 20 to 30 feet back from the open water and 50 feet apart.

The charge consists of several 1¼ x 8 inch cartridges of Red Cross Extra Dynamite 40 per cent. tied securely together with string, one of the cartridges having been primed with a Du Pont Waterproof Electric Blasting Cap. When the charges for all of the holes are prepared they are connected together and to the leading wires. Each charge is then lowered by ropes into the water and pushed under the downstream ice with the tamping stick. If the current is strong enough to carry the charge downstream the electric blasting cap wires should be long enough to let it float 6 or 8 feet below the holes. In a slow current a block of light wood may be fastened to each bundle of cartridges to make it float against the under side of the ice. The explosion of all of these charges simultaneously by the operation of the blasting machine will break up the first 50 or 60 feet of the channel and the broken ice will immediately float away unless the current of the stream is very sluggish. In that case the broken ice should be pushed out with poles into open water, before it has time to freeze in place again. This same operation is repeated, cutting out 50 or 60 feet or more of the channel with each blast until the gorge has been cut through. If the ice is from 2 to 4 feet thick the charge in each hole should be from two to five 1¼ x 8 inch cartridges of Red Cross Extra Dynamite 40 per cent. In ice from 6 to 8 feet thick, each charge must be increased to ten or twelve cartridges. When the ice is thick, and large charges are necessary, the holes have to be from 6 to 12 inches in diameter in order to get the bundle of cartridges through them. These large holes can be cut through the ice more easily by exploding half cartridges of the dynamite in small holes made with bars.

In this work particular attention should be given to having the dynamite in a well-thawed and soft condition when it is used, and to guarding against breaking the insulation of electric blasting cap wires or the pulling out of the wires by the force of the current.

Ice is blasted from watering places for stock either by exploding the dynamite on the ice or in the water under the ice.

Controlling Forest Fires

There are two kinds of forest fires: the overhead fire, where the flames leap from tree to tree, and the smouldering fire, which burns in what is called forest duff, a deposit of dried leaves and pine needles, sometimes a foot or two deep. Of the two, the

fire in the duff is perhaps more difficult to control, as it smoulders for a long time under the surface, sometimes under the snow, and is therefore difficult to detect at the distance of the observation stations and likely to break out in the open in several places at once.

The method heretofore adopted for controlling the latter kind of forest fire has been to dig a trench by hand. This blocks the progress of the fire and exposes sand or loam which can be thrown as an extinguisher on the burning material. By ditching with dynamite in the forest duff, it is possible not only to cut off the progress of the fire, and expose the sand and loam, but also to blow out the forest fire, as one would blow out a candle, by the blast from the gases of the explosion.

The ditching is done with a 20 per cent. Red Cross Extra, or straight dynamite. The electrical method of firing is used, with a No. 6 electric blasting cap in each cartridge. The holes should be placed about 2 feet apart and 18 inches deep, and should be made with a punch bar. This will usually make a ditch from 4 to 5 feet wide, 2 to 2½ feet deep, and any length desired, up to the capacity of the blasting machine. As an emergency measure, ditching across the path of a forest fire is undoubtedly a success, and an equipment of dynamite, electric blasting caps, blasting machines, and leading wires should be in the hands of every forest fire control station.

Excavating for Building Foundations

Dynamite is used in this work just as it is in other kinds of excavating, except that it is generally necessary to drill more and shallower holes and charge lighter because of the proximity of buildings and public thoroughfares. For additional protection from flying material the bore holes are frequently covered, before firing, with blasting mats and railroad ties. Red Cross 40 per cent. Extra Dynamite is recommended if the work is dry. If wet, Red Cross Straight Dynamite of the same strength should be used.

Razing Buildings

Dynamite has been found of great advantage in razing buildings which are in the pathway of large fires or which it is necessary to remove quickly for some other reason. Charges of 40 per cent. Red Cross Dynamite located under or against the principal supports will do the work quickly and completely. The quantity of dynamite necessary depends on the size of the support.

Breaking Up Old Machinery and Boilers

Metal castings can be broken up by firing charges of explosives on their surface as is done when mudcapping large rocks (see section headed "Quarrying"). The most economical method,

however, is to drill holes in them and blast exactly as described in the paragraph on blockholing under "Quarrying".

To cut up old boilers the dynamite should be removed from the wrapper or shell and laid in a compact train along the line of the desired cut or shear. This train should not be flattened or spread out laterally any more than necessary and should have a cross sectional area of, say, seven-eighths of a square inch. That is, a 1¼ x 8 inch cartridge should make about 16 inches of the train. The train should be covered carefully so as not to break it, with well-tempered stiff clay pressed firmly around the explosive, and should be detonated with a blasting cap crimped to the necessary length of fuse. If this is properly done the boiler plate will be cut through as with a shear. Bolt heads can be blown off very easily by firing a small charge of dynamite on them after it has been carefully covered with damp clay. Du Pont Straight Dynamite of 40 per cent. strength is recommended for this work.

Breaking Up Frozen Ore Piles

It is a general custom to store large quantities of ore and similar material in the open. This material is so loose that rain and snow water penetrate it even to the bottom of the piles. In cold weather the ore on the surface freezes into a solid crust several feet thick, so that it is impossible to handle it until it has been broken up. This can be done economically and satisfactorily only with dynamite. Best results will be had with comparatively heavy charges located in crevices or openings in the frozen ore. If the ore piles are on the docks and not large, the charges should be reduced to prevent damage to the docks. Red Cross Extra Dynamite, of from 30 per cent. to 40 per cent. strength, will usually give best results in this work.

Loosening Frozen Material in Railroad Cars

Coal, ore, sand, clay, rock ballast, or similar material occasionally freezes so hard in railroad cars that it is next to impossible to dislodge it. Charges consisting of a quarter or a half of a cartridge of Red Cross 40 per cent. Extra Dynamite, if located with good judgment, will not injure the car in any way and will prove of great assistance in breaking up the material so that it can be easily handled. The charges should be loaded into holes made with a crowbar or auger, or into crevices, and fired with electric cap and blasting machine.

High explosives have, from time to time, been of great advantage for purposes other than those described herein, but as these uses are not general it is unnecessary to refer to them in detail.

Shortage and Damage in Shipments

When a customer asks us for credit covering a part of a shipment which is missing, but is included on the railroad bill of lading, it is important that he furnish us with an acknowledgment of the shortage at destination over the signature of the railroad agent at the point where the shipment was received. All shipments from our works or magazines are carefully checked by experienced shippers before they are sent out and it is therefore probable that the missing material was lost en route. In this case, it is necessary for us to make claim for the value of the shortage and no claims of this nature are recognized by the transportation companies without this acknowledgment. When shortages occur in carload shipments, we request our customers also to give us positive information as to whether all car seals were intact when the car arrived at its destination and just what marks appeared on these seals.

In case a shipment or a part of a shipment arrives at its destination in a damaged condition, the customer is requested to decline to accept it and to obtain for us the railroad agent's acknowledgment in writing of the receipt of specified items in a damaged condition, so that we shall be able to recover their value from the transportation companies.

Investigation of Unsatisfactory Results

We are most jealous of the reputation of our explosives, and earnestly request all of our customers to notify us at once if they believe that the explosives are not giving the proper results. We request that we be notified and given an opportunity to investigate, even though the customer is not sure whether the poor results are due to improper use or defective explosives. If investigation shows that the explosives were defective when delivered to customer, we will make immediate and full adjustment. We ask the customer also to set aside the material for our examination and test and to preserve the cases and cartons in which it was received in order that, in case the material was sent out in a defective condition or below standard, we may have means of tracing the trouble to its source and of preventing its recurrence. In this way only can we trace the works at which the explosive was made and date of manufacture. We trust, therefore, that when trouble occurs our customers will advise us immediately and that under no circumstances will either the material itself or packages in which it was received be destroyed before the arrival of our representative.

☞ *A detailed description of all of the blasting accessories sold by the Du Pont Company, including instructions as to how they should be used, is given in our Blasting Accessories Catalog, a copy of which will be gladly furnished on application.*

General Precautions to be Observed with Regard to Explosives

DON'T forget the nature of explosives, but remember that with proper care they can be handled with comparative safety.

DON'T smoke while you are handling explosives, and don't handle explosives near an open light.

DON'T carry loose matches in your pockets while loading explosives; use safety matches.

DON'T shoot into explosives with a rifle or pistol either in or out of a magazine.

DON'T allow shooting or hunting near magazines.

DON'T leave explosives in a field or any place where stock can get at them. Cattle like the taste of the soda and saltpetre in explosives, and the other ingredients would probably make them sick or kill them.

DON'T handle or store explosives in or near a residence.

DON'T leave explosives in a wet or damp place. They should be kept in a suitable, dry place, under lock and key, and where children or irresponsible persons cannot get at them.

DON'T explode a charge to chamber a bore hole and then immediately reload it, as the bore hole will be hot and the second charge may explode prematurely.

DON'T do tamping with iron or steel bars or tools. Use only a wooden tamping stick with no metal parts.

DON'T *force* a cartridge into a bore hole.

DON'T have a wire carrying electric current near detonators or charged bore holes at any time except for the purpose of firing the blasts.

DON'T explode a charge before everyone is well beyond the danger zone and protected from flying debris. Protect your supply of explosives also from danger from this source.

DON'T hurry in seeking an explanation for the failure of a charge to explode.

DON'T drill, bore, or pick out a charge which has failed to explode. Drill and charge another bore hole at a safe distance from the missed one.

DON'T use two kinds of explosives in the same bore hole, except where one is used as a primer to detonate the other, as where dynamite is used to detonate Du Pont R. R. P. The quicker explosive may open cracks in the rock and allow the slower to blow out through these cracks, doing little or no work.

DON'T use a permissible explosive and another kind of explosive in the same bore hole, or two kinds of permissible explosives in one hole, or attempt to explode a permissible explosive with anything except a No. 6 or stronger detonator.

DON'T use frozen or chilled explosives. Dynamite other than the low-freezing kinds often freezes at a temperature between 45° F. and 50° F.

DON'T use any arrangement for thawing dynamite other than one of those recommended by the DU PONT COMPANY.

DON'T thaw dynamite on heated stoves, rocks, bricks, or metal, or in an oven, and don't thaw dynamite in front of, near, or over a steam boiler or fire of any kind.

DON'T take dynamite into or near a blacksmith shop or near a forge on open work.

DON'T put dynamite on shelves or on anything else directly over steam or hot water pipes or other heated metal surface.

DON'T cut or break a dynamite cartridge while it is frozen, and don't rub a cartridge of dynamite in the hands to complete thawing.

DON'T heat a thawing house with pipes containing steam under pressure.

DON'T place a hot water thawer over a fire, and never put dynamite into hot water or allow it to come in contact with steam.

DON'T allow thawed dynamite to remain exposed to a low temperature, but use as soon as possible.

DON'T paint roof black.

DON'T expose high explosives or detonators to direct rays of sun longer than necessary.

DON'T allow priming (the placing of a blasting cap or electric blasting cap in dynamite) to be done in a thawing house.

DON'T prime or connect charges for electric firing during the approach or progress of a thunder storm. If already primed, keep everybody away until the storm is over.

DON'T carry blasting caps or electric blasting caps in your pocket.

DON'T tamper with, pick at, or otherwise investigate a blasting cap or electric blasting cap.

DON'T attempt to take blasting caps from the box by inserting a wire, nail, or other sharp instrument.

DON'T try to withdraw the wires from an electric blasting cap.

DON'T fasten a blasting cap to the fuse with the teeth or by flattening it with a knife—use a cap crimper.

DON'T keep electric blasting caps, blasting machines, or blasting caps in a damp place.

DON'T leave the leading wires connected to the blasting machine. Disconnect them immediately, if necessary to return to the shot.

DON'T loop or tie the wire connections. Scrape the ends of the wires clean and bright and twist them tightly together.

DON'T drag the leading wires around; always coil them up and carry them.

DON'T allow the wires of an electric blasting cap to become tangled or kinked.

DON'T insert blasting cap or electric blasting cap in cartridges carelessly. Have closed end of detonator point toward the bulk of the charge and have it tied to the cartridge securely.

DON'T store or transport blasting caps or electric blasting caps with high explosives.

DON'T attempt to use electric blasting caps with the regular insulation in very wet work. For this purpose secure Du Pont Waterproof or Submarine electric blasting caps.

DON'T worry along with old, broken leading wire or connecting wire. A new supply won't cost much and will pay for itself many times over.

DON'T handle fuse carelessly in cold weather, for when cold it is stiff and breaks easily and should be warmed slightly before using.

DON'T store fuse in a hot place, as this may dry it out so that uncoiling will break it.

DON'T lace fuse through dynamite cartridges, and don't place several slit or broken cartridges on top of primer with cap and fuse. This practice is frequently responsible for the burning of the charge.

DON'T cut the fuse short to save time. It is dangerous and wasteful of explosive, as it is impossible to tamp such charges properly.

DON'T operate blasting machines half-heartedly. They are built to be operated with full force. They must be kept clean and dry.

DON'T expect a cheap article to give as good results as a high-grade one.

DON'T expect explosives to do good work if you try to explode them with a detonator weaker than a No. 6 (red label).

Glossary of Terms Used in the Explosives Industry

Air shot.—A shot fired with the charge loaded in contact with an air space for the purpose of lessening its shattering effect.

Adobe or 'doby.—See *Mudcap.*

Back holes.—In shaft sinking or raising, the round of holes which are shot last.

Bag.—A paper container 1 to 2 inches in diameter and 8 to 18 inches long, called a tamping bag, used for placing an inert material such as sand, clay, etc., into a bore hole for stemming or tamping.

A paper container holding 12½ pounds of Du Pont R. R. P.

Barricade.—An artificial mound of earth, usually as high as the eaves of a magazine roof, erected to deflect the force of an explosion upward and to protect the building enclosed from flying objects.

Battery.—See *Blasting machine.*

Blasting barrel.—A piece of iron pipe, usually about ½ inch in diameter, used to provide a smooth passageway for the miner's squib. It is recovered after each blast and used until destroyed.

Blasting cap.—A copper shell closed at one end, containing a charge of detonating compound which is ignited from the spark of the fuse. Used for detonating high explosives.

Blasting circuit.—The leading wires, connecting wires, and connected electric blasting caps, when prepared for the firing of a blast.

Blasting gelatin.—A high explosive, consisting of nitroglycerin and nitro-cotton. It is the strongest explosive known, and is a rubber-like, elastic substance, unaffected by water.

Blasting machine.—A portable dynamo, in which the armature is rotated by the downward thrust of the rack bar or handle. Used for firing blasts electrically.

Blasting mat.—A tightly woven covering of heavy manila rope or wire rope, or chain, made in various sizes, for covering the material to be blasted and preventing the flying of small fragments of rock.

Blasting powder.—A variety of gunpowder, made from saltpetre or Chili saltpetre, charcoal, and sulphur, formed into grains of uniform size, used for blasting.

Blasting accessories.—A term used to include electric blasting caps, ordinary blasting caps, fuse, blasting machines, galvanometer, rheostats, etc.; in fact, everything used in blasting, except explosives.

Blistering.—See *Mudcap.*

Blockhole.—A small hole drilled in a block of rock either by hand drill or a portable air drill, to contain small charges of explosives.

A relief hole, designed to remove part of the burden from a subsequent shot, used in coal mining.

Blow-out.—A blast which fails to dislodge the material desired and spends all its force in blowing out the tamping through the bore hole.

Bore hole.—A hole bored in the rock, coal, ore, or other material, into which explosives are loaded for blasting the material away from its original position.

Bottom.—To break the material and throw it clear from the bottom or toe of the bore hole.

Breaking-in shot.—The first bore hole fired in blasting off the solid or a hole fired to provide a space into which material from subsequent shots may be thrown.

Breast holes.—Relief holes used in tunneling, fired after the bottom cut.

Brushing shot.—A charge fired in the air of a mine to blow out obnoxious gases, or to start an air current.

Bridge wire.—The fine platinum wire which is heated by the passage of an electric current to ignite the priming charge of an electric blasting cap or an electric squib or of a similar device.

Bug dust.—The fine coal or other material resulting from a boring or cutting of a drill, sometimes improperly used as a tamping or stemming material in coal mining.

Bulldoze.—See *Mudcap.*

Burden.—The distance between the charge and the free face of the material to be blasted.

Buster shot.—See *Breaking-in shot.*

Butt shot.—A shot for which the charge is placed so that the face or burden is nearly parallel to the bore hole. Used in coal mining.

Cap.—See *Blasting cap.*

Cap crimper.—See *Crimper.*

Carbonite.—A permissible explosive, with a short flame and low velocity of detonation, which withstands water fairly well.

Carton.—A pasteboard box made to contain high explosives, blasting caps, or electric blasting caps, packed in numbers in a wooden case for shipment.

Cartridge.—A cylindrical waterproof paper shell, filled with high explosive and closed at both ends.

Case.—A wooden box in which dynamite is shipped.

A wooden box in which cartons of electric blasting caps, boxes of blasting caps, or coils of fuse are shipped.

Case markings.—The letters or figures stenciled or printed on the front of a case containing explosives indicating the size, weight, kind, strength, date, and place of manufacture.

Center cut.—The bore holes drilled to include a wedge-shaped piece of rock and fired first in the heading of a tunnel.

Chambering.—See *Springing.*

Charge.—The explosive loaded into a bore hole for blasting; also any unit of an explosive, as a *charge* of nitroglycerin or a *charge* of detonating composition in the blasting cap.

Charging.—The loading of a bore hole with explosives.

Chilled.—The condition of the dynamite when subjected to a low temperature which is not cold enough to congeal it but seriously affects its strength.

Churn drill.—See *Well-drilled holes;* also a hand-operated drill, with a cutting bit on either end and a weight welded at the center operated by the lifting and dropping of its own weight against the rock to be drilled.

Collar.—The mouth or opening of a bore hole.

Combination shot.—A blast made by dynamite and permissibles or permissible explosives and blasting powder in the same hole. It is bad practice and in many states is prohibited by law.

Connecting.—The operation of joining adjacent electric blasting cap wires to each other, to connecting wire, and to the leading wires in such a way that an electric current will flow through with the least possible resistance.

Connecting wire.—A wire of smaller gauge than the leading wire used for connecting the electric blasting cap wires from one bore hole to those of an adjoining one.

Coyote hole.—Same as gopher hole. A tunnel of small size, usually just large enough to admit a man, driven into the solid rock and charged with an explosive for blasting. It is driven horizontally into the rock at right angles to the face of the quarry and has two or more cross-cuts driven from it parallel to the face. It is in the ends of these cross-cuts that the explosive charge is generally placed, and the remaining space in the tunnel is filled up with rock, sand, timbers, or concrete, to act as stemming or tamping.

Crimp.—The flattening made near the mouth of a blasting cap for holding the fuse in place.

Crimper.—An instrument for making the crimp.

Cut holes.—The first round of holes fired in a tunnel or shaft.

Delay electric blasting cap.—A detonating device with a delay element between the priming and detonating composition. It detonates about one or two seconds after the electric current has passed through the bridge. It is made in two kinds—first and second delay—and is used in connection with regular, water-

proof, or submarine electric blasting caps for blasting in tunnels, shafts, etc., where it is desirable to have charges fired in succession without the necessity of the blaster returning between the blasts.

Delay electric igniter.—An electrical device using fuse as the delay element by which it is possible with the use of a blasting cap on each fuse to detonate a number of charges in succession.

Detonation.—The conversion of a solid into gases with extreme rapidity, as in the case of high explosives such as dynamite.

Detonator.—A device, such as a blasting cap or an electric blasting cap, used for detonating a high explosive.

Ditching.—The digging or making of a ditch by the use of explosives. See *Propagated blast.*

Ditch wiring.—The method of connecting electric blasting caps in such a way that the two free ends can be connected at one end of the line of holes.

'Doby.—See *Mudcap.*

Dope.—The absorbent or active base of a dynamite.

Double load.—A load in a bore hole separated by a quantity of inert material for the purpose of distributing the effect, or preventing part of the charge blowing out at a seam or fissure. In the latter case the inert material is placed so as to include the seam.

Duck's nest.—The cavity made at the bottom of a bore hole by springing. See *Springing.*

Dummy.—A paper bag filled with sand, clay, etc., for tamping or for separating two charges in a double-loaded bore hole.

Duobel.—A permissible explosive of low density and high strength, suitable for mining coal, salt, gypsum, and softer ores.

Duplex wire.—Two insulated copper leading wires wrapped together with paraffined cotton covering.

Du Pont R. R. P.—An explosive intermediate between blasting powder and dynamite, and partaking somewhat of the character of both. It is a black substance containing sulphur, charcoal or coal, and nitrate of soda, formed into non-porous grains and mixed with nitroglycerin.

Dynamite.—Originally, an explosive made of 75 per cent. nitroglycerin absorbed in 25 per cent. kieselguhr. Now, any high explosive containing explosive ingredients used for blasting purposes.

Electric blasting cap.—A device for detonating charges of explosives electrically. It consists essentially of a blasting cap, in the charge of which is buried a fine platinum wire stretched across two copper wires protruding from a plug of sulphur composition which holds them in place. The heating of the platinum wire bridge by the electric current ignites the explosive charge in the cap, which in turn detonates the high explosive.

Electric blasting.—The firing of one or more charges electrically, whether electric blasting caps, electric squibs, or other electric igniting or exploding devices are used.

Electric exploder.—A former designation for electric blasting cap.

Electric detonator.—The term used in England and in Canada for electric blasting cap.

Electric squib.—A device similar to an electric blasting cap, but containing a gunpowder composition which simply ignites but does not detonate an explosive charge. Used for electric firing of blasting powder.

Exploder.—The term used in England to designate an electric blasting machine.

Explosive.—Any mixture or chemical compound that may explode by sudden combustion or decomposition.

Extra dynamite.—The present designation of those explosives consisting chiefly of nitroglycerin, nitrate of ammonium, nitrate of soda, and an active base absorbent. They are more easily affected by water than straight dynamites, but give off less noxious fumes, are less sensitive to blows, and ignite from sparks less easily than straight dynamite.

Face.—The free surface, generally more or less vertical, of a quarry or mine or tunnel heading.

Firing machine.—A designation for the electric blasting machine.

Follow-up tag.—The cardboard tag placed in the cartons, boxes, or cases of blasting accessories, used for identifying the date and place of manufacture.

Flagging a squib.—Uncoiling the end of the paper which is impregnated with sulphur or some other combustible substance. Flagging the squib permits more time to elapse between the ignition of the unrolled paper and the firing of the charge of powder.

Flat cut.—A manner of placing the bore holes for the first shot in the tunnel in which they are started about 2 or 3 feet above the floor, pointed downward so that the bottom of the hole is about level with the floor.

Front.—A designation for the mouth or collar of a bore hole.

Fulminate.—A common designation for fulminate of mercury. The principal explosive ingredient in the ordinary detonators. It is an exceedingly sensitive substance and, when ignited by means of a hot wire or spark from a fuse, it explodes with very great suddenness. It is used practically only for detonating high explosives.

Fumes.—The gases and smoke, more especially the noxious or poisonous gases given off by the explosion or detonation of blasting powder or dynamite.

The character of the fumes is influenced largely by the completeness of detonation; therefore, the degree of confinement of the charge and the size of the detonator has a great influence on the character of the fumes produced.

Fuse.—A core of black powder wrapped with hemp or cotton threads or with tape, for the firing of explosives, either with or without a blasting cap. The wrappings and the waterproof compounds which are on the outside or between the layers of wrappings, when there is more than one, serve to make the burning speed of the powder uniform. Fuse usually burns at the rate of about 2 feet per minute, and is made in various grades, depending on the amount of water it is required to withstand.

Fuse lighter.—A device for facilitating the ignition of the powder core of a fuse. One form is in the shape of a carpet tack covered with a powder composition; another form is in the shape of a cord, which, when ignited, burns and maintains a "coal of fire" which may be touched to the exposed powder in the fuse.

Fuze.—(Pronounced as though spelled "fuzee".) Originally the device used for exploding the bursting charge in a projectile. Now a designation for an electric blasting cap.

Galvanometer.—Strictly speaking, a galvanometer is an instrument for determining whether a circuit is closed or open. The Du Pont Galvanometer is also a direct reading ohmmeter, as it contains a resistance coil by which it is able to measure the resistance of a blasting circuit.

Gelatin dynamite.—A high explosive consisting of nitroglycerin and guncotton, made into a jelly with which is mixed the absorbent or active base. It is a plastic, waterproof high explosive, of high density, used principally for close work and wet work.

Gelignite.—The term by which gelatin dynamite is known abroad.

Granulation.—The term applied to any one of the several sizes into which the grains of blasting powder are made and sorted.

Gob.—The waste rock in coal and other mines which is left in the mines, usually piled up between the different rooms or headings.

Gopher hole.—Same as a coyote hole. It is sometimes used as a designation for any horizontally drilled hole, usually on a level with the quarry floor.

Grade.—The degree of strength of a high explosive. Those above 40 per cent. are arbitrarily designated as "high" grade and those below 40 per cent. strength as "low" grade dynamites.

Guhr.—See *Kieselguhr*.

Gun.—A bore hole in which the charge of explosive has been fired with no other effect than to blast off a small amount of material at the mouth of the bore hole. Also called a boot-leg or "John 'Odges".

Guncotton.—A nitro-cotton of the highest nitration, containing the greatest possible percentage of nitrogen. Sometimes called insoluble cotton. It is used as a bursting charge for submarine mines and for demolishing bridges and other structures in warfare.

Hang-fire.—Condition in which a charge fails to explode at the expected time but explodes later. A hang-fire rarely occurs with electric firing, but is not infrequent with blasting cap and fuse.

Heel.—The mouth or collar of a bore hole.

High explosives.—Explosives which detonate or are composed of ingredients which detonate. In the United States the designation covers explosives such as gelatin, dynamite, blasting gelatin, etc.

High grade.—An arbitrary designation of dynamite of 40 per cent. strength or over. See *Grade.*

John 'Odges.—See *Gun.*

Keg.—A cylindrical container made of steel or some other substance, which holds 25 pounds of blasting powder or gun powder.

Kettle.—See *Thawing kettle.*

Kieselguhr.—An absorbent earth composed of the calcined skeletons of fossil diatoms. It was formerly used as the only absorbent for nitroglycerin in the original dynamite. It is an inert substance or passive base, whose only value lies in its capacity to absorb about three times its weight in nitroglycerin.

Leading wire.—A cotton-covered copper wire, usually No. 14 gauge, used for connecting the two end wires of the circuit of electric blasting caps to the blasting machine or the power circuit.

Legs.—The wires attached to and forming a part of an electric blasting cap.

Lifters.—Bore holes for blasting which are drilled horizontally or nearly so, usually at about the floor level.

Low explosives.—A term sometimes used to designate explosives which do not detonate, such as blasting powder, in distinction to high explosives, such as dynamite.

Low-freezing dynamite.—A dynamite that does not freeze until a temperature below 32° F. is reached, and even then only after prolonged exposure, as contrasted with the dynamites that freeze normally at 45° F.

Low grade.—An arbitrary designation of dynamites of less strength than 40 per cent. It has no bearing on the quality of the materials, as they are of as great purity and high quality as the ingredients in a so-called "high grade" explosive.

Low powders.—High explosives containing a small proportion of nitroglycerin and a base similar to blasting powder. Intermediate between blasting powder and dynamite in action.

Misfire.—The failure of a charge to explode when expected. In electric firing it is generally due to a broken circuit or insufficient current. If the electric blasting cap fires without exploding the charge, it is probable that a detonator has been misplaced or the charge has been affected by storage in a wet place. Misfires with fuse and blasting caps are generally due to the fuse going out or to the failure of the fuse to ignite the blasting cap. Failure of the blasting cap to detonate the dynamite, when it is fired, is usually due to its having been affected by dampness.

Monobel.—A permissible explosive characterized by the production of a short flame, low temperature, and velocity of detonation. There is very little smoke from the explosion of Monobel and practically no poisonous fumes.

Mudcap.—A charge of dynamite or other high explosive fired in contact with the surface of a rock after being covered with a quantity of wet mud, wet earth, or sand, no bore hole being used. The slight confinement given the dynamite by the mud or other material permits part of the energy of the dynamite to be transmitted to the rock in the form of a blow. A mudcap may be placed on top or to one side, or even under a rock, if supported, with equal effect.

Needle.—A piece of copper or brass about ½ inch in diameter and 3 or 4 feet long, pointed at one end, and turned into a handle at the other, tapering from the handle to the point. It is thrust into a charge of blasting powder in a bore hole, and while in this position the bore hole is tamped up solid, preferably with moist clay. The needle is then withdrawn carefully, leaving a straight passageway in the tamping through which the miners' squib can shoot to fire the charge.

Nitro-cellulose.—A term used to include the various nitrates of cellulose, such as guncotton, nitro-lignine, nitro-cotton, nitro-jute, etc. The most common of these is nitro-cotton.

Nitro-cotton.—A chemical combination of ordinary cotton fibre and nitric acid. It is explosive, highly inflammable, and in certain degrees of nitration, soluble in nitroglycerin.

Nitro-glycerin.—A chemical combination of glycerin and nitric acid. It is an oily substance about one and one-half times as heavy as water (SP. GR. 1.6,) almost insoluble in water, and is used as a principal or active ingredient in dynamite, gelatin dynamite, etc. It is not used commercially in the form of a liquid, except for "shooting" oil wells.

Pasting.—The operation of mudcapping.

Permissible explosives.—Explosives which have passed certain prescribed tests by the Bureau of Mines of the Department of the Interior, of the United States Government, and which are not likely to cause ignition of mine gases, coal dust or of a mixture of the two, and are for use in coal mines. The government does

not require the use of permissible explosives, but recommends their use in gaseous and dusty mines.

Plastering.—Same as mudcapping. See ***Mudcap.***

Plug hole.—Same as *Block hole.*

Point.—The end or bottom of a bore hole, as distinguished from the mouth or collar.

Pop shot.—Same as block hole shot, See *Block hole.*

Primer.—A dynamite cartridge, or package of any explosive, which contains the detonator, whether blasting cap or electric blasting cap.

Priming.—The operation of inserting a detonator into a cartridge and fastening it thereto.

Propagated blast.—A blast, generally for the purpose of ditching, consisting of a number of unprimed charges of explosives and only one primed charge, in which each charge is detonated by the explosion of the adjacent one, the shock being transmitted through the wet soil. In this method, one detonator fired in the middle of a line of holes is capable of bringing about the explosion of several hundred such charges.

Quickness.—The property of an explosive by virtue of which it exerts a sharp blow or shattering effect on the material with which it is in contact. The quickest explosive of the dynamite class is the 60 per cent. straight dynamite. Quick explosives are the ones particularly desired for mudcapping. For maximum effect for this purpose, they should be of high density and sensitiveness.

Red Cross explosives.—A class of high explosives manufactured by the Du Pont Company in the gelatin, straight, and extra grades, characterized by the low-freezing point.

Reel.—A device on which leading wire is wound to avoid kinking and breaking the wire and to keep it in good condition.

Relief holes.—Bore holes which are loaded and fired for the purpose of relieving the charges to be fired in the main blast of part of the burden.

Rheostat.—An instrument for inserting varying resistance in an electric circuit for controlling the intensity of an electric current. The Du Pont rheostat is an instrument for testing blasting machines by inserting definite resistance equal to a known number of electric blasting caps of a standard length wire, with the use of one electric blasting cap as an indicator.

Rib shots.—The shots fired in holes drilled next to the sides of the room or tunnel. In mining or tunneling, the rib is the portion of the material to be blasted corresponding to the side walls of a room.

R. R. P.—Railroad powder. An explosive somewhat similar to gunpowder, consisting of grains of assorted sizes, made in

such a way that the grains are not porous, having nitroglycerin on the surface which is not absorbed by the grain. See *Du Pont R. R. P.*

Saltpetre.—Nitrate of potash. The principal ingredient in "A" blasting powder.

Sand blast.—A mudcap in which sand is used instead of mud.

Sensitiveness.—The property of a high explosive which permits it to be exploded by a shock. The more insensitive an explosive is, the stronger detonator it requires to develop the full strength.

Scrapping.—The breaking up of metal castings, plate, etc., with explosives, generally by mudcapping.

Shaking.—The same as *Springing.*

Short fuse.—A fuse which is not long enough to reach from the top of the charge to the collar of the bore hole, making it necessary to load the primer while the fuse is burning and to tamp hastily and insufficiently or not at all. The use of short fuse is an exceedingly dangerous practice.

Short leg.—A wire on an electric blasting cap which has been shortened so that, when loaded in the bore hole, the two splices or connections will not come opposite each other and make a short circuit.

Side spit.—The emission of sparks through the sides of a burning fuse.

Snake hole.—A bore hole driven horizontally or nearly so and approximately on a level with the quarry floor; also a bore hole driven under a boulder for containing a charge of explosives. In quarry work it is called a "lifter."

Socketing.—Same as *Springing.*

Spitting.—Lighting the fuse.

Springing.—The enlarging of a bore hole at the bottom by the successive firing of increased charges of explosives, usually with a quick-acting dynamite. The number of times that a hole must be sprung to give the desired result can be determined only by experiment.

Squib.—A paper tube filled with a powder composition which, when lighted at one end, burns for a few seconds, and then ignites the powder composition and shoots like a rocket through the bore hole, or through a blasting barrel placed in the bore hole, into the charge of blasting powder which it ignites. Used principally in coal mining.

Squib shot.—A blast with a small quantity of high explosives fired at some point in the bore hole for the purpose of dislodging some foreign material which has fallen into it.

Squibbing.—See *Squib shot.*

Stemming.—Term used by the Bureau of Mines to designate the inert material used for confining the force of an explosive and

also for the process of placing this material in the bore hole. Same as tamping.

Storage.—The keeping of explosives in a magazine.

Straight dynamite.—A high explosive made in strength from 20 to 60 per cent., consisting essentially of nitroglycerin and an active base or absorbent.

Submarine blast.—Firing of high explosive in bore holes drilled in the rock under water for the purpose of dislodging dangerous projections and deepening channels.

Subsoiling.—The firing of small charges of dynamite 2 or 3 feet below the surface for breaking up impervious strata of soil, clay, etc., for aerating, draining, and moistening the soil.

Tamping.—Term used in the United States to designate the material used for confining charges of explosives in bore holes, the placing of the material and packing of it in the bore hole, and in some sections the packing of the high explosives in the bore hole. The last is not a desirable use of the word.

Thawing.—The warming of frozen dynamite to a point where it becomes soft and plastic. It should be done carefully, slowly, and according to directions issued by the manufacturers of the explosives.

Thawing kettle.—A double kettle, built somewhat like a farina boiler, having two compartments, the outer compartment, which is filled with hot water, entirely surrounding the inner compartment, which contains the dynamite to be thawed. It is provided with a lid for holding the heat.

Thawing house.—A small building for thawing dynamite, of such a size as to hold enough thawed dynamite for a day's work. Thawing houses should be heated either with hot water or exhaust steam, in such a manner that the explosives cannot come in contact with the heated metal or lie directly over the heated metal.

Toe.—The burden of material between the bottom of the bore hole and the free face. It is sometimes used to designate the bottom of the bore hole itself as distinguished from the heel, collar, or mouth of the bore hole, which is the open end.

Transportation.—The moving of explosives from distributing point to magazine and from magazine to thawing house or point of consumption.

Tunneling.—The driving of a tunnel for a passageway for railroad trains and the like; also a method of quarrying, in which a T-shaped tunnel is drilled in the rock, a large hole being driven, usually directly into the face of the rock, for several feet, from the end of which two branches are driven in opposite directions at right angles to the first hole, the ends of this T being filled with large quantities of explosives, and the intervening spaces and

the main tunnel, with inert material as an ordinary bore hole is loaded.

Undercut.—A term used in coal, and some other kinds of mining, to designate a cutting out by mechanical means of a portion of the material to be removed in order to facilitate blasting operation. It is usually done on the level of the floor of the mine, extending laterally along the entire face and 5 or 6 feet into the material.

V-Cut.—In mining and tunneling, a cut where the material blasted out is like the letter V in plan. Usually consists of six or eight holes drilled into the face, half of which form an acute angle with the other half.

Velocity of detonation.—The velocity with which the detonation or explosion of a mass of explosives travels through the mass itself.

Well-drill holes.—Holes drilled by means of an apparatus known as the well drill, or by a similar apparatus, used for blasting on a comparatively large scale. Such holes are usually 5 or 6 inches in diameter and from 30 to 150 feet deep.

Well shooting.—The firing of a charge of nitroglycerin, or other high explosive, in the bottom of a well for the purpose of increasing the flow of water, oil, or gas.

Well sinking.—The driving of a well, usually over 3 or 4 feet in diameter, to a depth not exceeding 30 or 40 feet.

Windy shot.—A blast in coal mines which, because of improperly placed charges, the wrong kind of explosives, or insufficient tamping, ignites a gas mixture and causes a secondary explosion which may or may not spread throughout the mine.

For a complete glossary of terms used in mining, see "A Glossary of the Mining and Mineral Industry", by Albert H. Fay, published by the Bureau of Mines, Department of the Interior.

The High Explosives Catalog

is printed in two sections—this being the First Section.

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The Second Section covers Kinds, Grades and Brands of Du Pont High Explosives.

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A copy of the Second Section will be sent on receipt of a request addressed to our Advertising Division.

E. I. du Pont de Nemours & Co.
Incorporated
Wilmington, Delaware

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